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Agent-enhanced Electronic Classroom on the Web

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13. ABSTRACT (*Maximum 200 words*)

This report documents a Phase I STTR effort to develop a prototype Agent-Enhanced Electronic Classroom (eClass) that uses intelligent agents as tutors and coaches. In this Phase I project, we worked alongside the UMass Dartmouth Division of Continuing Education to investigate an electronic classroom architecture which will complement the training objectives of the Five Pillars of the WF XXI Campaign. The architecture developed incorporates intelligent software agent technology capable of personalizing course content to each student. The eClass prototype was completed during this Phase I effort, and is available through the web at http://agents.cra.com/eclass . The selected training content for the prototype involves learning how to interpret aviation weather reports. The eClass Agent allows students to navigate through course content (a coded weather report), bringing the student quizzes and exams when the student has reviewed the corresponding material. The agent corrects the exams and coaches the student through additional material. Evaluation of the prototype eClass was conducted primarily at the Eastern Aviation Army National Guard Training Site in Ft. Indiantown Gap, Pennsylvania. The Phase I prototype can easily be customized for any number of web-based training materials providing a high commercial potential.

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Project Summary

This report documents a Phase I STTR effort to develop a prototype Agent-Enhanced Electronic Classroom (eClass) that uses intelligent agents as tutors and coaches. In this Phase I project, we worked alongside the UMass Dartmouth Division of Continuing Education to investigate an electronic classroom architecture which will complement the training objectives of the Five Pillars of the WF XXI Campaign. The architecture developed incorporates intelligent software agent technology capable of personalizing course content to each student.

The eClass prototype was completed during this Phase I effort, and is available through the web at *http://agents.cra.com/eclass* . The prototype requires a Netscape 3.0 (or higher) browser running on Windows 95/NT operating systems. The selected training content for the prototype involves learning how to interpret aviation weather reports. The eClass Agent allows students to navigate through course content (a coded weather report), bringing the student quizzes and exams when the student has reviewed the corresponding material. The agent corrects the exams and coaches the student through additional material. The eClass architecture also provides links to external resources, a question & answer agent that communicates with an instructor, and a student notepad for personal course notes.

Evaluation of the prototype eClass was conducted primarily at the Eastern Aviation Army National Guard Training Site in Ft. Indiantown Gap, Pennsylvania. Two sets of students were given access to the web-based weather eClass as a supplement to their in-class aviation training. Feedback from the first group of students was used to improve the eClass interface and delivery mechanisms, enabling the second group of students to successfully utilize the eClass weather training to improve their knowledge and performance.

This Phase I effort has produced two significant prototypes with high commercial potential. The first is a general agent-enabled electronic classroom framework that can easily be customized for any number of web-based training materials, including interactive Java simulations. The second potential product is a Multimedia Question & Answer Agent that can be used within any eClass, or as a stand-alone interactive agent, to provide direct and immediate answers to questions posed over the web (*http://agents.cra.com/q&a*). The prototyped Q&A Agent is easily customizable through a Q&A Administration agent, to be used as web FAQ administration agents, tech support, or interactive help desks. Both the eClass and Q&A Agents are currently being evaluated in commercial web sites and on-line university courses.

Acknowledgments

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Ray Llewellyn of the Army Aviation Center and School, Fort Rucker, Alabama, provided access to the aviation weather program of instruction. Sergeant Scully and Catherine Cole, from the Army National Guard Media Center at Fort Rucker, Alabama, provided technical support for the weather training lessons. Sergeant Faull from the Western Aviation Army National Guard Training Site provided aviation weather report content review. Greg Stone, from UMass Dartmouth, provided management of our university partnership, assisting with the current technology survey and electronic classroom evaluation. Kent Norman, from the University of Maryland, served as evaluation consultant on this project.

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1. Introduction

Training, according to the Chief of Staff of the Army, is "the cornerstone of readiness" and as such "remains the Army's most important peacetime mission" (Lengyel, 1996). In particular, the Army needs cost-effective and efficient training techniques and materials, given the increasingly sophisticated and informed threats in today's worldwide battlefield. WarFighter XXI (Lengyel, 1996) describes the Army's vision for training in the 21st century. The Army Long Range Training Plan of WF XXI outlines a plan to implement a distance learning program by moving portions of resident training from classrooms to soldiers at home station. Some of the goals of the Army's distance education program (Lengyel, 1996) are to:

- train Commanders in military tactics and procedures, the art of leadership, and map reading and visualization,
- train both *active and reserve* warfighters to survive on both the physical and the digital battlefield,
- use advanced technologies to teach more students with fewer instructors,
- lower costs through decreased travel and housing costs, and
- automate course production and eliminate redundant courses.

The Standard Army Training System (SATS) and Training Support Package (TSP) are two of the five components of WF XXI. These programs include tools for providing instructors with training templates, matrices and aid in the management of training resources. The stakeholders in the distance education program include the instructional designers (i.e., those involved in designing SATS and TSP), the unit trainers (i.e., those responsible for selecting training material), and the students (commanders and soldiers).

Table 1-1: Internet Enabling Technologies

Type	Technologies
Content presentation	Hypertext, Shockwave, quicktime video, Java, VRML, Real-Audio, CU-SeeMe
Communication	Email, listsrv, MUDs, MOOs, newsgroups, chat rooms, video conferencing, Look@Me
Knowledge discovery and off-line automation	Metalists, search engines, virtual libraries, online news, USENet, softbots, agents
Electronic classrooms	WEST, HyperCourseware, CyberEd

Internet technologies including those listed in table 1-1 have seen an explosion in growth and usage over the past several years (Witten, Moffat & Bell, 1994). The introduction of the internet

and related technologies offers an opportunity to expand the potential of computerized training by removing the physical boundaries defined by traditional training techniques: Internet-based or web-based training (WBT) offers a venue for students to learn in a *virtual* or *electronic classroom* by exploring and learning from centrally stored curriculum materials, and collaborating and communicating with instructors and peers via email and online forums.

Numerous examples of electronic classrooms have appeared in recent years. HyperCourseware (Norman, 1994) is a prototype system for the preparation and presentation of materials in an electronic teaching environment. It consists of a Home Screen and a set of interconnected modules organized into three groups: Course Materials, Course Products, and Course Tools. HyperCourseware runs in either the Windows or Macintosh environments. WEST (WEST, 1996) is an example of a commercial virtual classroom product that provides remote authoring and administration facilities to create course content and manage students. WEST runs over networks such as the Internet and corporate networks and it features online course pages, built-in email and discussion forums and electronic homework submission capabilities. CyberEd (Stone, 1996) is a selection of standard, full-credit University courses being offered to the global audience of the Web through the UMass Dartmouth Division of Continuing Education. CyberEd uses the World Wide Web, email, and other Internet resources, to provide opportunities for meaningful student-to-faculty and student-to-student interaction.

In this Phase I effort, Charles River Analytics worked alongside the UMass Dartmouth Division of Continuing Education to investigate an "agent-enhanced electronic classroom" architecture which complement the training objectives of the Five Pillars of the WF XXI Campaign. The architecture expands on the CyberEd concept by incorporating *intelligent software agent* technology capable of personalizing course content to each student. Intelligent software agents are self contained software programs that operate in computer environments such as operating systems, databases, and applications. The combination of knowledge, inference, and communication components of an agent results in behavior that is intelligent in the sense that the agent has sufficient expertise and ability to complete a task autonomously with little or no human intervention.

Table 1-2 summarizes the features, advantages, and benefits of our proposed agent-enhanced electronic classroom architecture. Agents and electronic classrooms offer the Army a versatile training tool and medium which will benefit the Army as a whole as well as each of the distance education stakeholders (designers, trainers and students). We believe that this tool has potential in the Army, government and commercial sectors.

Table 1-2: Features, Advantages, and Benefits of agent-enhanced electronic classroom

Feature	Advantages	Benefits
Extensible and flexible architecture	Can be centralized, decentralized, networked or standalone	Customize architecture and security to suit needs
Platform independent software	Runs on mainstream hardware (PCs, Macs, workstations)	No need to purchase new hardware and software
Centralized course content repository	Course content can be updated immediately	Reduced production and distribution costs and time
Flexible course participation	Students can view material at any time of day, in familiar surroundings, and at any rate	Students learn at their own pace
Intelligent agents	Learns user's current and persistent information interests	Personalizes web training content, promotes discovery learning, alerts trainer to student weaknesses

1.1 Phase I Technical Objectives

The objective of this Phase I effort was to assess the feasibility of developing an architecture for an agent-enhanced electronic classroom that incorporates agent technology. Basic questions addressed during the effort were:

- How can we develop an architecture for an electronic classroom that is flexible and extensible?
- How can the architecture be prototyped using the CyberEd concept? What kinds of hardware and software are necessary to build an electronic environment? What are security provisions?
- How can the architecture be enhanced with agent technology? In particular, how can intelligence be incorporated into the architecture? What kinds of intelligent advice can it offer? What are the ramifications of embedded intelligence on the instructional designer and/or trainer?
- In general, what are the features of courses that can be successfully taught via an electronic classroom? Can we use a local ROTC program to prototype an Army course to demonstrate feasibility?
- How will such an architecture benefit the Army? How can the five Pillars of WF XXI benefit? How will the distance education stakeholders (designers, trainers and warfighters) benefit?
- What criteria will be used to evaluate the agent-enhanced electronic classroom prototype? How can evaluation be conducted?

The Phase I effort addressed these questions and demonstrated feasibility of the approach through on-line prototypes and student evaluations. As a result of this effort, we are in a position to outline a Phase II program of full-scope prototype design and development.

1.2 Summary of Phase I Results

Our Phase I study centered on the development and feasibility assessment of an agent-enhanced electronic classroom for the web. Six development tasks comprised our effort:

- Identification of State-Of-The-Art in Electronic Classrooms
- Determination of Prototype Lesson Domain
- System Architecture Design
- Implementation of a Limited-Scope Prototype
- Demonstration and Evaluation of Concept Prototype
- Requirements Specification and Commercialization

We first defined the Phase I **problem scope**. This involved consultation with the sponsor, through which we selected the *interpretation of aviation weather reports* as the lesson content for the prototype electronic classroom. The following requirements for the Phase I effort were identified:

- The lesson content must have inherent structure that can be navigated by students.
- The lesson must be testable through multiple choice questions
- The tutor agent must monitor student progress through content
- The tutor agent must administer exams and provide coaching
- The electronic classroom must demonstrate multimedia capabilities
- The electronic classroom must be extensible to other lesson content
- The agent tutor must facilitate student-instructor interaction and communication

With the problem scope and requirements identified, the target lesson content was selected to be a limited subset of the Army National Guard Aviation Training course. The selected subset of aviation training was Interpreting Aviation Weather Reports. This is a component of the MOS 93P Aviation Operations Specialist Course that mold to the METAR format. This content provided a complete lesson that could be presented in its entirety, while remaining small enough to complete in the Phase I timeframe.

The agent-enhanced electronic classroom (eClass) architecture was chosen such that it would be easily extensible for additional in-depth content and to other lesson domains. To accomplish this, a Java-based client-side implementation was used along with Cold Fusion server-side connections to a MS Access database. All relevant lesson content information is stored within MS Access tables and HTML files, while the Java code contains the agent tutor rules and general

eClass functionality. In this manner, lesson content can be easily modified and replaced without changing the basic functionality of the eClass and its agent tutor.

The eClass architecture was prototyped for the aviation weather report training, and is available at *http://agents.cra.com/eclass* for demonstration purposes. The results obtained from this Phase I prototype effort can be summarized as follows:

- a three-frame approach to the eClass user interface provides a consistent learning environment in which there are designated areas for student self-paced navigation, agent tutoring interaction, and lesson content presentation.
- the eClass client-server architecture is capable of accommodating a large range of training content, providing easy customization for developers and simplified maintenance for instructors.
- the Agent tutor is effective in monitoring student navigation through course content, capable of administering exams when needed, successfully corrects exams, and provides accurate coaching for areas the student had difficulty with.
- the Question & Answer Agent component of the prototyped eClass successfully provides direct and accurate answers to student questions, decreasing the load on actual course instructors.
- the Question & Answer Agent component is capable of serving as a stand-alone service, and was demonstrated for the commercial OpenSesame web site, Charles River Analytics intranet, and UMass Dartmouth CyberEd course.
- the prototyped eClass for Weather training was evaluated by two groups of Army National Guard students. Feedback from the first group of students was used to modify the agent functionality for the second group. The second group of students successfully completed the eClass training using the on-line prototype.

Based on the results of our Phase I effort, the agent-enhance eClass architecture has significant commercial potential for military, university, and corporate training applications.

1.3 Report Outline

This report summarizes and documents our Phase I STTR effort to develop and evaluate a prototype agent-enhanced electronic classroom for the internet environment. Chapter 2 presents a background on the web-based training domain in addition to research conducted during Phase I. Chapter 3 discusses the training pedagogy and introduced the selected training content for the

developed prototype. Chapter 5 presents the detailed eClass architecture and prototype implementation. The prototype evaluation is summarized in Chapter 6 with detailed results shown in Appendix A. The Phase II requirements and commercialization concepts are presented in Chapter 7 with final project summary and conclusions in Chapter 8.

2. Background

This chapter provides technical background on past research and current technologies most relevant to our effort to develop an agent-enhanced electronic classroom.

2.1 Web-based Training Evolves from Computer-based Training

Over the years, computer-based training (CBT) has evolved from linear and text-based systems into user-centered, instructional systems that utilize graphics, photographs, animation, sound and motion video. Such software is often called multimedia. Authoring tools such as Director, Visual Basic, SuperCard and HyperCard allow developers to focus more on the instructional benefits of multimedia than on the technical hurdles required to build them. The commercial, industrial, military and government sectors recognize the effectiveness and cost benefits of well-designed CBT, which are enhanced by self-paced and any time/place delivery. A study revealed that students retain 70% of information taught through CBT and only 10% taught through lecture (Lager, 1994).

A major weakness of CBT is that applications require software and hardware. CBT applications are susceptible to changes in both the operating system platform and content and applications are difficult to economically and quickly update. CBT can also be difficult or expensive to port to other platforms.

Web-based training represents an evolution of the concept of CBT. It also presents solutions to the many problems posed by CBT. The advantages and benefits of WBT include:

- Applications are usually written in a standard language (HTML), an open standard.
- Applications run on multiple platforms (Windows, Mac, UNIX).
- Content can be easily and remotely updated.
- The course author can link to other materials drawing on the global resources of the Web to enrich the lessons.
- Content can be viewed at any time and rate and in familiar surroundings (this also obviates the need to schedule classes, instructors and classrooms).
- Software for presenting the course is inexpensive (both browsers and servers are available for free on the Internet).

In addition to being used to publish course content, WBT can also incorporate technology which will provide the capability for communication and collaboration among students and their

peers and between students and their professors. Testing students via the Internet to verify they have assimilated information is also possible with this technology.

2.2 State-Of-The-Art Research

A study of current research in the area of CBT and WBT has identified the following centers and organizations of interest:

The **Web-Based Training Information Center** is a non-profit resource for individuals and organizations interested in developing and delivering training using Web technology. The intent of this site is to share non-proprietary information, stimulate creative ideas, and link to interesting training sites around the world.

The **ITI Online Training Center** is a collection of on-line courses designed to help you quickly master a variety of computer-related topics.

Prentice Hall is delivering Online Applications to supplement a number of their books.

The **IT (Information Technology) Works CD-ROM** represents a new generation in college-level courseware. IT Works is an innovative multimedia educational tool that can work one-on-one with students to interactively demonstrate many important computer concepts and applications. This extremely visual and interactive courseware employs sound, motion video, colorful high-resolution graphics, and animation.

PHLIP is a content-rich, multi-disciplinary business Web site created by professors for professors and their students. With PHLIP, faculty and student support moves into the information age. It is intended to create a web based "Learning Environment" that will consist of numerous links to websites, a current events reporting feature, online chat, and bulletin board functionality. It is fully prototyped, and will evolve to reference a considerable amount of text/media assets from our Bus Publishing archive.

MetaKnowledge is developing new software technology for interactive learning via the internet. The company is currently developing its first product named MetaKnowledge Builder. This new technology will enable the rapid production and management of high quality knowledge based online content. The company was founded by Rick Spitz, previously Vice President of Software at Apple Computer in Cupertino, California.

Engines for Education ASK systems are a form of hypermedia based on the metaphor of having a conversation with an expert (or a group of experts). In this conversation, the user provides questions and the ASK system provides the answers. In a real conversation, both participants influence the flow of discussion. In an ASK system, the same holds true. The user

influences the flow by selecting which questions to pursue and the ASK system influences the flow through the answers it provides.

2.3 Distance Learning Projects

Although formal standards do not exist for creating electronic classrooms, numerous training sites are paving the way by offering examples of how courses can be taught online. A complete education environment, according to Norman, 1994, requires a pedagogical structure, interactivity, and hypermedia.

HyperCoursware (Norman, 1994) uses the conventional objects of classroom instruction and implements them in electronic form in the electronic classroom.[2] Objects such as the course syllabus, the lesson plan, the lecture notes, the class roll, etc. are instantiated in graphic form in a hypermedia database. Furthermore, in HyperCourseware the hypermedia database is used to provide the same sort of natural links between objects as one would expect in the educational materials themselves. For example, the syllabus is a natural navigational mechanism to jump to lectures, readings, and assignments; the classroll is a natural navigational jump to information about students and grades; and the grade list is a natural navigational jump to exams and assignments. Each of these are syntactic navigational links in support of education.

CyberEd (Stone, 1996) is a selection of standard, full-credit University courses being offered to the global audience of the Web through the UMass Dartmouth Division of Continuing Education.[3] The objective is to create a distance learning environment that rivals the traditional classroom environment in both the quality and content of the learning experience. Thirteen courses are currently being offered to students over two semesters (Fall '95 - Spring '96) with several more coming up in the summer. Enrollment is limited in CyberEd–one of the goals of the program is to keep the student/instructor ratio to a size where professors can provide the same level of personal interaction as in the traditional classroom. Another cornerstone of the program is the focus on communication: CyberEd uses the World Wide Web, email, and other Internet communication resources such as Chat, listsrvs, and web-based conferencing systems to provide plenty of opportunities for meaningful student-to-faculty and student-to-student interaction. The program, like HyperCourseware, emphasizes the importance of communication and collaboration between students and instructors.

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[2]See URL: http://www.lap.umd.edu/hcwFolder/hcwHome.html

[3]See URL: http://www.umassd.edu/cybered/distlearninghome.html

Calvin College-- Cyberspace for Beginners. Course Description: IDIS W29 was an 1996 Interim (January term) course offered by the Department of Communication Arts and Sciences. This course reflects the basic structure of the CyberEd process. Much of the language in the description resembles that used in CyberEd promotional materials. "Use the Internet to research intensively a topic of the student's choice and write a hyperlinked "paper" based entirely on Web sources."

Economics Department - University of Colorado. Here's a process that although somewhat narrow in scope defines the basic process by which an instructor creates content for his or her students: "The hypertext nature of the Web allows the teacher to direct students not only to essential material but also to other relevant materials available on the Web... the course designer/instructor adds links to more tangential course elements that the instructor has written or links to other Web sites which contain complementary information...The Web can be used in many different ways, from providing a simple set of references to a complete compilation of course materials."

The World Lecture Hall (http://www.utexas.edu/world/lecture/) contains links to pages created by faculty worldwide who are using the Web to deliver class materials. For example, you will find course syllabi, assignments, lecture notes, exams, class calendars, multimedia textbooks, etc.

CASO's Internet University (http://www.caso.com/index.html) has more than 1,130 pages of ONLINE ED information, provided to the Educational and Internet communities as a service of CASO (Cape Software).

2.4 Enabling Internet Technologies

This section describes most of the enabling internet technologies from table 1-1, and highlights their strengths in training applications.

2.4.1 Content Presentation Technologies

Content presentation technologies present information such as text, video, sound and images to the user. Some of these technologies are interactive, requiring a response from the user. Other information is static, containing information for the user to read, listen to or view. Static information is usually presented in a linear synchronous format. Examples of technologies for presenting content are described in table 2.4-1.

Table 2.4-1: Content Presentation Technologies

Technology	Definition	Best Training Use
Hypertext	Electronic versions of a printed document. Hypertext, or hottext is text that is linked to other pages.	Presenting text
Java	Programming Language which allows applications to be run on any platform supporting a Java enhanced web browser.	Custom-made interactive applications
VRML	Virtual 3-D graphical scenes which the user can move through and "experience".	Custom made interactive applications which require third dimension
Shockwave	Software which allows users to interact with Director presentations (animations, buttons, URL links, videos) in a Netscape Navigator window.	Custom made interactive Director applications
Real Audio	Provides live and on-demand real-time audio over the Internet.	Presenting sound
Quicktime Video	Provides ability to view movies through web browser.	Presenting video clips
CU-SeeMe	Software with whiteboard and real-time audio which can be used for video conferencing from workstation to workstation across the Internet.	Whiteboard and real-time audio could be used to create content between students and instructors.

2.4.2 Communication Technologies

Technologies which allow users to communicate with each other utilize such media as text, video, bulletin boards and sound. Such technologies allow for collaboration and are essential for teams to collaborate and interact over a distance. Some communication technologies are defined in table 2.4-2.

Table 2.4-2: Communication Technologies

Technology	Definition	Best Training Use
Email	Method for sending correspondence to another individual electronically.	One-to-one correspondence which is not time sensitive.
Listsrv	online discussion which allows participants to send identical email messages to all the members of a list.	One-to-many correspondence which is not time sensitive.
MUD, MOO	Text-based and graphics-based virtual environments that provide a shared space and activities for participants.	Collaboration and communication among two or more individuals in real-time. Good medium for role playing.
Chatroom	Text-based environment where users can discuss (by typing) common interests.	One-to-one or one-to-many collaboration. Good medium for meetings, office hours.
Look@Me	Provides ability to view another Look@Me user's screen anywhere in the world in real time.	Collaboration on documents in real time.
CU-SeeMe	Software used for video conferencing from workstation to workstation across the Internet.	One-to-one or one-to-many communication requiring video and sound capabilities.
Web phone	Internet-based phone systems which eliminate long distance calls.	One-to-one audio communication. Could be used in conjunction with Look@Me.

2.4.3 Knowledge Discovery and Off-line Automation Technologies

Internet technologies which promote knowledge discovery give users the power and knowledge to explore the Internet in greater depth. Such tools support the discovery learning theory which is a form of instruction in which students can find their own answers to questions. Technologies which do not require user to be present to conduct work via the Internet. Some knowledge discovery and off-line automation technologies are described in table 2.4-3.

Table 2.4-3: Knowledge Discovery and Off-line Automation Technologies

Technology	Definition	Best Training Use
Search engines	Tools which search the World Wide Web and produce lists of sites which best match the users search criteria.	Locating resources and references in real-time or while the user is not present.
Online news	News archive sites.	Reference for newsworthy events.
USEnet	Worldwide network of information bulletin boards which anyone can post to.	Reference for information pertaining to any discussed topic, and forum for asking questions.
Softbots	Intelligent software agents which are given a task such as finding information, updating information or purchasing information on the Internet on behalf of their owner.	Discovery understanding of new information.
User Interface Agents	Intelligent software which observes the user's behavior and offers to automate repetitive behavior or teach concept.	In-context tutoring, dynamic creation of content and tests based on user interests.

2.4.4 Open Sesame User Interface Agent

Open Sesame! is the first desktop agent that learns to automate the routine tasks of a user. Open Sesame! has been reviewed and covered in trade and mainstream publications worldwide from the New York Times to the Japanese edition of PC Week. Open Sesame! has been shipping since December 1993, and is distributed worldwide. Currently, we are shipping version 1.1 of Open Sesame! which is specifically optimized for Apple Macintosh computers using the PowerPC RISC chip. (This version is also available for downloading from our Web page.)

Here, we discuss Open Sesame! as an example of a software learning agent. Open Sesame! version 1.0 watches for two kinds of tasks: *time-based* and *event-based* (Mazzu, Snorrason, Caglayan & Wilkinson, 1994). A time-based task is something that the user does at a particular time. For example, opening electronic mail every day at nine o'clock is a time-based task. An event-based task is something that the user does in relation to another task. For example, opening the clock desk accessory before logging into an online database is an event-based task.

Open Sesame's architecture is based on hybrid neural network/expert system technology (Mazzu, Caglayan & Jonas, 1991) and is shown in Figure 2.4-1.

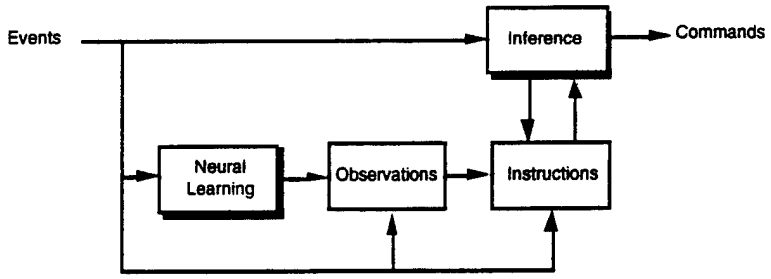

Figure 2.4-1 Open Sesame! Architecture

Open Sesame! compares the high level events (like opening a folder, quitting an application and so on) generated by the user's mouse clicks and keystrokes to information stored in its neural learning module and in its inference engine. The neural learning module looks for repetitive patterns that haven't been automated. If it finds one, then Open Sesame! creates an *observation*, such as the one shown in figure 2.4-2.

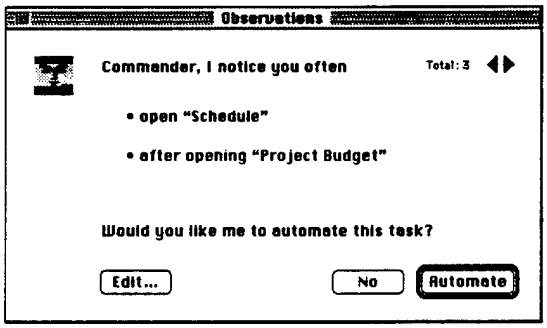

Figure 2.4-2: Observation Dialog Box

If the user gives her/his approval, then Open Sesame! creates an *instruction* to automate the task that it observed. The inference engine compares monitored user event patterns with patterns for existing instructions. When it finds a match, Open Sesame! automatically sends a set of events to the operating system to perform the instruction.

The pattern recognition in Open Sesame! uses a neural network paradigm called GEN-ART (Caglayan & Snorrason, 1993; Snorrason & Caglayan, 1994), based on Adaptive Resonance Theory (Carpenter, Grossberg & Rosen, 1991) to categorize the high level events it monitors. One advantage of ART type networks is their provision for self-organized learning, which does not require prior knowledge of event-pattern categories. This is accomplished via bottom-up competitive filtering of patterns for finding the "best match" category, combined with top-down template matching for determining if the best match is "good enough." GEN-ART allows the use of customized distance metrics to handle input patterns with qualitative (nominal or ordinal) variables.

3. Pedagogy and Lesson Content

There are several key areas in which the work for this contract speaks directly to pedagogical issues. To understand the benefits of this work in this regard, it is important to understand what educators and training professionals look for in learning technologies — what they hope to gain in using new learning technologies in the classroom.

Discussions in Usenet news and on educational listserves regarding technology in the classroom are replete with controversy and conflict. While many perspectives exist, for the benefit of brevity, this report will focus on two opposing views.

3.1 Pedagogical overview

There is a model of distance learning that says communication between the student and instructor does not need to take place at all, or at least it does not need to be as direct or immediate as in traditional classrooms. Proponents of this perspective support the self paced, self regulated approach to instructional design and favor the methods set forth in Computer Based Training (CBT).

There is another camp that propounds a model of distance learning in which the student/instructor relationship is emphasized and technology is looked to as a means to better the flow of communication between student and mentor. Proponents of this model frown upon automated tasks or any features that distance the instructor from interacting with students.

It is the opinion of this author that a synthesis of these two perspectives is the key to successful development of agent technology.

3.2 Pedagogical Advantages of Agents

A successful implementation of agent technology in today's marketplace will satisfy the needs and expectations of all pedagogical assumptions and biases. The way to bridge the gaps between parties is to focus on what technology can do for the student.

The agent has the ability to administer quizzes, freeing instructors from the task of deciding when to give quizzes as well as the actual time devoted to taking them in class. This benefit could easily be extended and made more elaborate to provide completely automated courses in which the instructor is entirely absent from the learning experience. But what is more toward the point of developing a commercially and educationally viable product is to ask if an automated course is in the student's best interest or whether it would be better to include the instructor but free him to fulfill other roles.

In a keynote address given to the UMass Instructional Technologies Conference, 1997, Professor James Noblitt, a senior fellow at the Institute for Academic Technologies and a member of the Department of Romance Language at the University of North Carolina, Chapel Hill, identified three key areas to which all new learning technologies should make a contribution. He related that new technologies' greatest strengths reside in the issue of authenticity from the student perspective.

- **Authenticity of content**: Learning technologies should expose students to as much primary data as possible. The artifice of textbooks often removes students from the actual information they are required to assimilate, analyze, or manipulate. New technologies can bring primary sources of information to the learning experience without taking the learning experience out of the classroom.
- **Authenticity of outcome**: Learning technologies should assess and evaluate student performance and skill level according to real world criteria. New technologies can ensure that students actually understand the material presented through application of genuine professional criteria either through workplace simulations or direct feedback from professionals in the field.
- **Authenticity of role**: Learning technologies should allow instructors to stick to their role as facilitator, freeing them from the need to invent roles to guide and evaluate student outcome. This can be seen as a by-product of the first two areas; new technologies allow primary sources of data and feedback from professionals in the field to fulfill the role otherwise invented by the instructor.

In the next section, we introduce the selected lesson content domain for the Phase I effort and show how these three key areas of authenticity are addressed.

3.3 Lesson Content - Interpreting Aviation Weather Reports

The selected lesson content for this eClass prototype was the Interpretation of Aviation Weather Reports. This is one section of the Military Occupational Speciality (MOS) 93P10 Aviation Operations Specialist training course. This content was selected for the following key features:

- it has a well defined structure that can me modeled in the eClass format
- the content can be tested using multiple choice questions

- subject matter experts are readily available for course evaluations
- computer based training for this content was not yet developed by the Army
- the content would benefit from multimedia such as graphics, audio and video

As illustrated below in figure 3.1-1, a typical weather report can be divided into 10 sections:

Format	Location ID	Wind	Visibility	Weather Elements	Runway Visual Range	Sky and Ceiling	Temp and Dew Point	Altimeter Setting	Remarks
METAR	KCSG	24025SQ45	1/4SM	FG FZRA	R32L/1200FT	BKN080	01/M01	A2932	RMK CIG006V010

Figure 3.1-1: Aviation Weather Report Sections

With this natural content structure, the lesson can be organized into discrete content areas that the student can navigate through, and that the coaching agent can monitor and provide guidance on. This content is evaluated according to the three key authenticity concepts outlined in the previous section:

- **Authenticity of content:** The Aviation Weather module provides an excellent example of how this can be accomplished. The navigational menu used throughout this site is an actual weather report with hyperlinks placed over each key data field. A primary source of data is used in the design, preparing students for what they will see in the field.
- **Authenticity of outcome:** The Aviation Weather training is based on actual MOS 93P10 Aviation Operations Specialist training content that is used in Army National Guard training around the country. Exams and quizzed administered by the eClass agents are the same ones given to students at Army training locations.
- **Authenticity of role**: The agent can function as a personal assistant for the instructor. One example of this is its ability to administer and grade evaluative material. In addition, the agent developed for this content is able to answer student questions and provide feedback, therefore taking the load off the instructor. Professors using the Internet for distance learning need to be freed from this role so they can focus on the content of their course. Teachers who cannot fulfill the role of technical guru might be convinced to use this method of educational delivery if agent technology can mitigate the need to seek outside help.

4. System Architecture

4.1 Electronic Classroom Architecture

The architecture of our agent-enhanced eClass is shown below in figure 4.1-1. Here, we have designed and implemented a Java-based eClass agent to run on the student's local web browser and resides within the eClass HTML interface. As shown, this client-side eClass agent communicates back to an NT server to access the learning capabilities of Learn Sesame in addition to storing and accessing knowledge of the students and the lesson content.

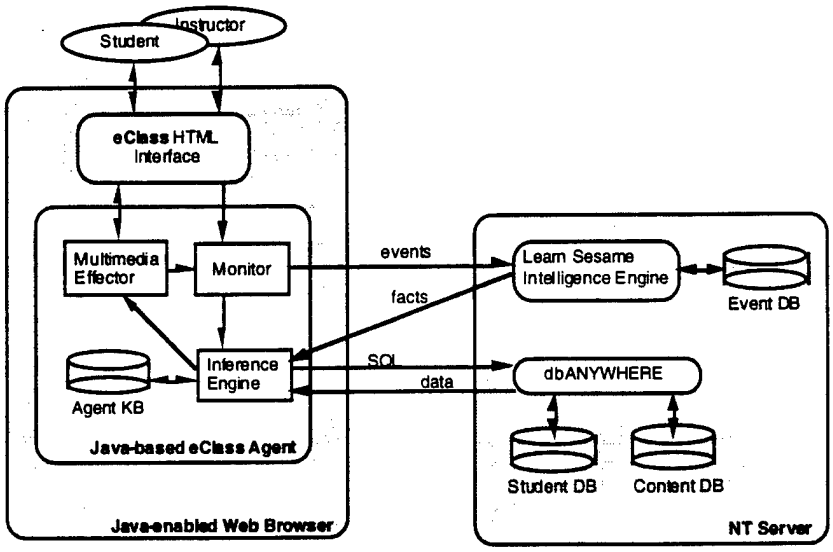

Figure 4.1-1: Agent-Enhanced eClass Architecture

The eClass agent is the heart of the eClass architecture and controls all that the student and instructor interact with. It includes the real-time inferencing capabilities and keeps a local copy of its high level training and administration knowledge within an Agent Knowledge Base (KB). All knowledge and data that the agent learns is stored on the server for long-term access. To accomplish the Java to ODBC communication, we take advantage of Allaire's Cold Fusion software. The Learn Sesame intelligence engine is provided with continual user events by the agent. Since the Learn Sesame engine stores its own history of events, it can provide immediate feedback to the agent if it learns a new fact any time an event is processed.

4.2 Electronic Classroom Interface Design

The Aviation Weather eClass prototype employs a three part frames structure, which includes the agent coach area, the content whiteboard, and the student navigation workdesk. Figure 4.2-1 illustrates this three frame HTML eClass interface:

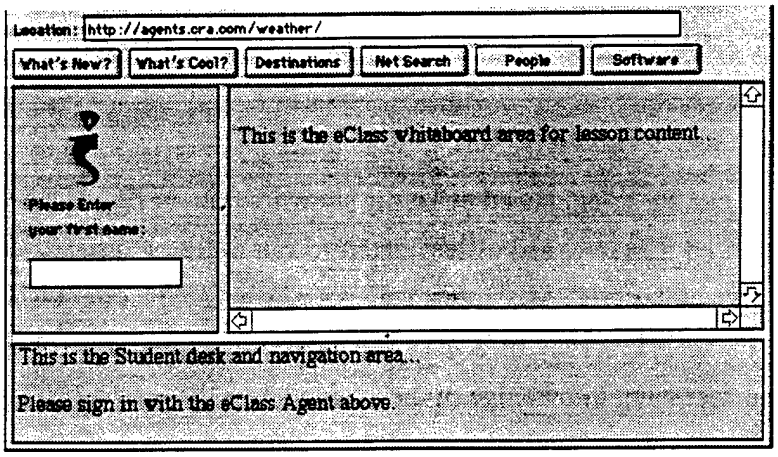

Figure 4.2-1: eClass Interface

This has technical advantages, which will be discussed below, but also makes for a more intuitive user interface. Each frame window has a clearly defined purpose for the user:

- **Coaching Agent frame**: This is the upper left portion of the browser window and is reserved for the Java applet that "speaks" to the database and contains the rules for coaching and monitoring student progress and performance. In the weather module, this is the place where quizzes and quiz results are offered along with a place to ask questions, an opportunity to take notes and a link to the overview of the course content. This last item functions as a panic switch that brings students back to the top of the lesson content in case they get lost or disoriented.

- **Content Whiteboard frame**: This is the large frame window to the right in the browser window. This is where the main body of a lesson's content is displayed. Care was taken to make this area as large as possible, thereby reducing the need to scroll and improving readability.

- **Student Navigation frame**: This is the short horizontal frame window that traverses the bottom portion of the browser window. This is where a navigational menu is displayed to the user that brings together the entire lesson. The design of this navigational structure as implemented in the Weather and WebCraft modules represents an effort to convey where in the lesson the student is and how much information the overall site contains. A yellow highlight appears on the menu item that corresponds to the information the student is seeing in the content frame.

The navigational issues addressed in this design are perhaps the most noteworthy. The problem of place and context has plagued the web development community for some time. Sarah Horton and Patrick Lynch, Directors of the Yale Center for Advanced Instructional Media, point out the challenge of providing effective navigation through a web site is in imparting a sense of location:

> Readers need a sense of context, of their place within an organization of information. In paper documents this sense of 'where you are' is a mixture of graphic and editorial cues supplied by the graphic design of the book, the organization of the text, and the physical sensation of the book as an object.
>
> Horton, Lynch, *Web Style Guide*, 1997.
>
> http://info.med.yale.edu/caim/manual/interface/navigation.html

4.2 eClass Design Advantages

Contextual placement: Course content is supported by an intuitive navigational scheme that conveys a sense of where in the lesson a particular element resides. At the same time, the frames interface prevents navigational structures from getting in the way of content.

Ease of use: Navigation is possible no matter where a student has scrolled to in the content frame. This eliminates a step and reduces the potential for frustration.

Flexible sequencing: Training materials should have linear, rigid paging functions. Limiting links to Next and Previous pages is a common practice. Extraneous links to outside resources only confuses the overall message of a lesson. However, students who return to the same lesson for retraining or to reinforce the message of a lesson find this too restrictive. The design of navigational elements in the Weather eClass provides a clear sequence for students to follow in learning the skill, but also allows a great amount of flexibility. Students may skip from one section of the lesson to another without losing place or context.

Consolidation of functionality: A significant advantage to instructors and content providers seen in the prototype eClass is an integration of key course activities. Questions can be asked by students and answered by the agent without the need to launch any outside software application. Email messages are automatically sent to the content provider when questions cannot be answered using the content in the agent database. The frames structure allows as many as three separate pages of information to be displayed, allowing for more opportunities to relate one piece

of information to another or to an alternate medium such as sound or video, or to a larger context held in an outside resource.

Multimedia: Low bandwidth solutions are used to deliver both audio and video sources of information. The Weather eClass makes use of sound files (.au) to simulate how weather personnel would speak data to a pilot.

5. Prototype Implementation

5.1 Implementation Design

A Java applet working in conjunction with a database can be a very powerful tool for educators interested in web based instruction. Agent technology as used in this Phase I project provides a viable means of tracking student involvement in each lesson, scheduling and administering of student evaluations, and answering student questions.

The technology used to bring course content together with a database and user preferences involves creation of a Java applet. The agent developed in this contract can be seen as consisting of three elements: a database, a Java applet, and the HTML files that make up a course web site. Using JavaScript within the HTML files, data objects are created that can be passed to the applet and in turn stored in the database. In the quizzing area, for example, student responses are passed to a JavaScript that invokes a function in the applet specifically designed to accept the answers and categorize them as pass or fail. This same process can be used in many ways. Each time a student visits a page by clicking on a link, a JavaScript function is activated that requests the page from the Java coaching agent, who then logs that activity in the database.

5.2 Prototype eClass System Requirements

To limit the testing requirements for the prototype, the target ***client*** platform was chosen as the following:

- Netscape 3.0 or higher running on Windows 95/NT

The prototype ***server*** requirements are the following:

- Windows NT
- Microsoft Information Server
- Allaire Cold Fusion ODBC connection server

The prototype eClass client can also be viewed on Macintosh operating systems running Netscape 3.0, however there are known problems with the Gold version of Netscape that may cause errors while running eClass.

5.3 Student Logon

The developed prototype can be accessed at *http://agents.cra.com/eclass/weather* , and will prompt the student for a name and password as illustrated in figure 5.3-1:

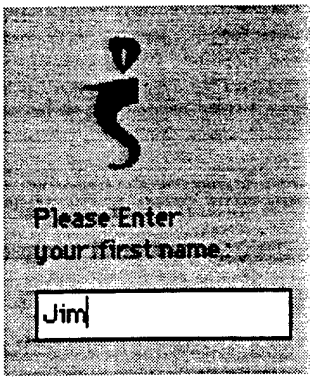

Figure 5.3-1: eClass Agent Interface

If the agent has not seen the particular student before, it will ask for a password. When the student enters his/her own personal password, the agent automatically creates a new account for that student.

5.3 eClass Course Overview

After a student enters the agent-enhanced eClass, he/she is free to navigate throughout the content at their own pace. The agent assists the beginner by presenting the content overview in the content whiteboard frame as shown in figure 5.3-2:

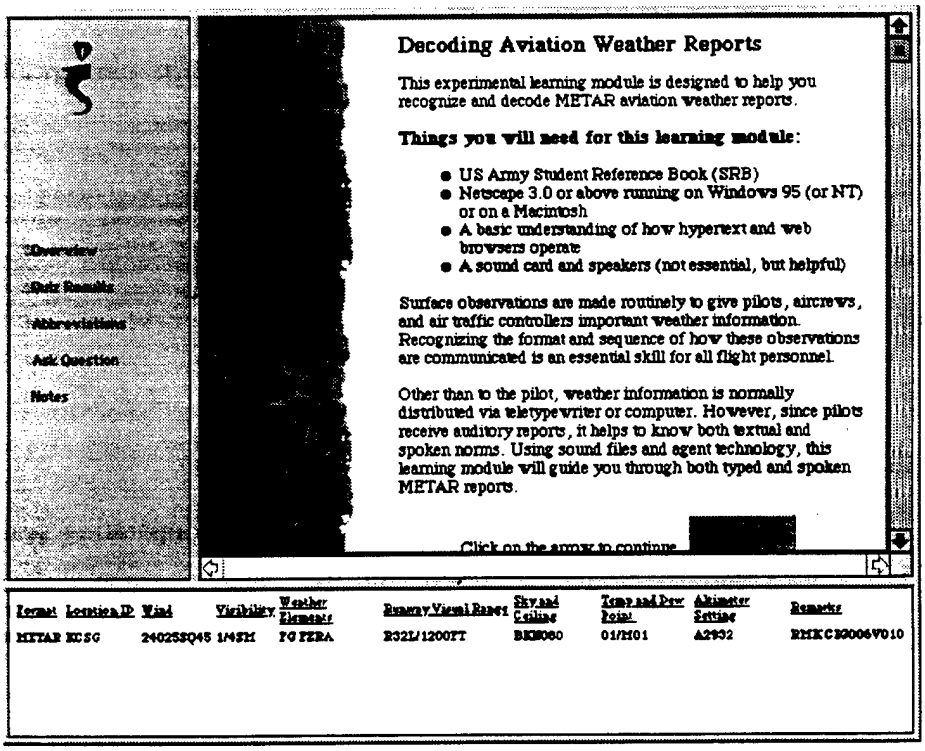

Figure 5.3-1: Weather eClass Content Overview

Students can then step through the content overview using the large blue navigation arrow. When the student has completed the overview, the coaching agent guides the student to the first section of the weather report. This serves to get the student acquainted with the eClass system, while introducing the weather content material.

5.4 Agent Administration of Exams

The coaching agent monitors the student's progress through the course and administers the exams as it determines when the student is ready for a quiz (figure 5.4-1).

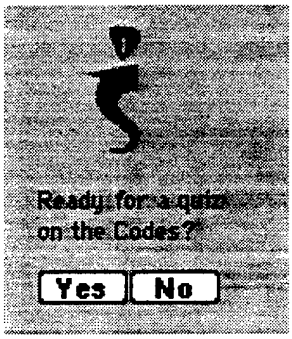

Figure 5.4-1: Agent Automatically Administers Quiz

The coaching agent then scores the student's results, providing feedback, and guiding the student through additional instruction. The coaching agent insures that the student is not overloaded with exams and allows the student to advance only after successfully completing lower level exams.

The completed prototype contains training material completely supported by the eClass coaching agent. The training consists of the following quiz material:

- Quiz on weather codes
- Quiz on Wind section
- Three intermediate level Practical Exercises
- Two advanced level Practical Exercises

Figures 5.4-1 and 5.4-2 illustrate a sample quiz and exam that is administered by the coaching agent:

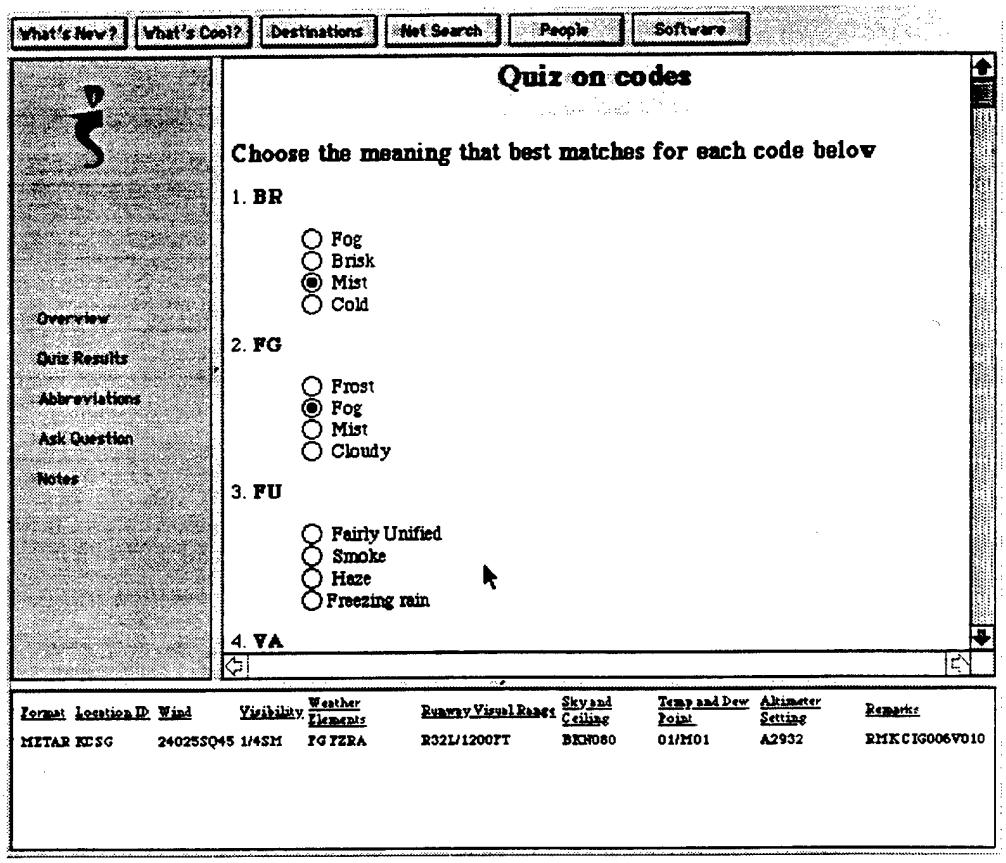

Figure 5.4-1: Weather eClass Codes Quiz

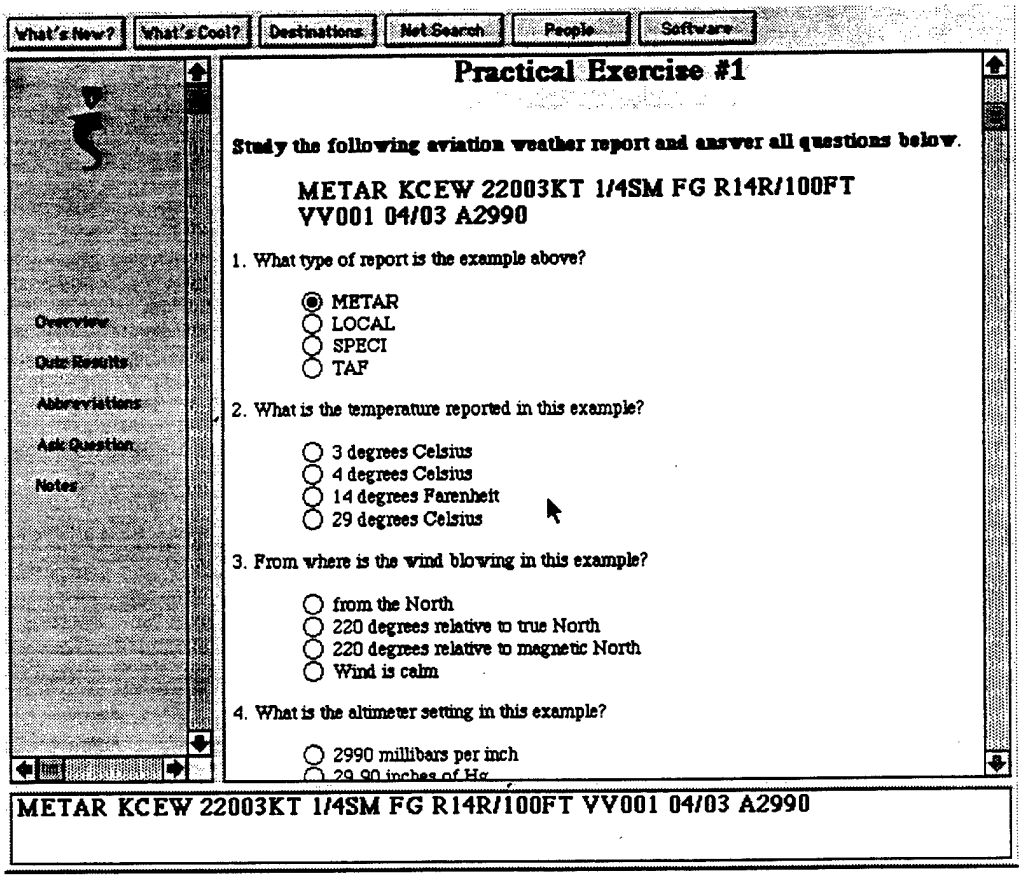

Figure 5.4-2: Weather eClass Sample PE Exam

As illustrated, the eClass agent administers quizzes and exams in the form of multiple choice questions. The exams are brought to the student only after they have looked at the corresponding content material. Students are allowed to return to course content before completing the exam to review additional material. If so, the agent continues to bring the incompleted exam to the student until they successfully complete it.

After completing a quiz or exam, the coaching agent reviews the student's answers and analyzes the results. Based on the attributes of each individual question, the agent then determines which content area the student requires additional guidance through. A sample quiz result is shown in figure 5.4-3:

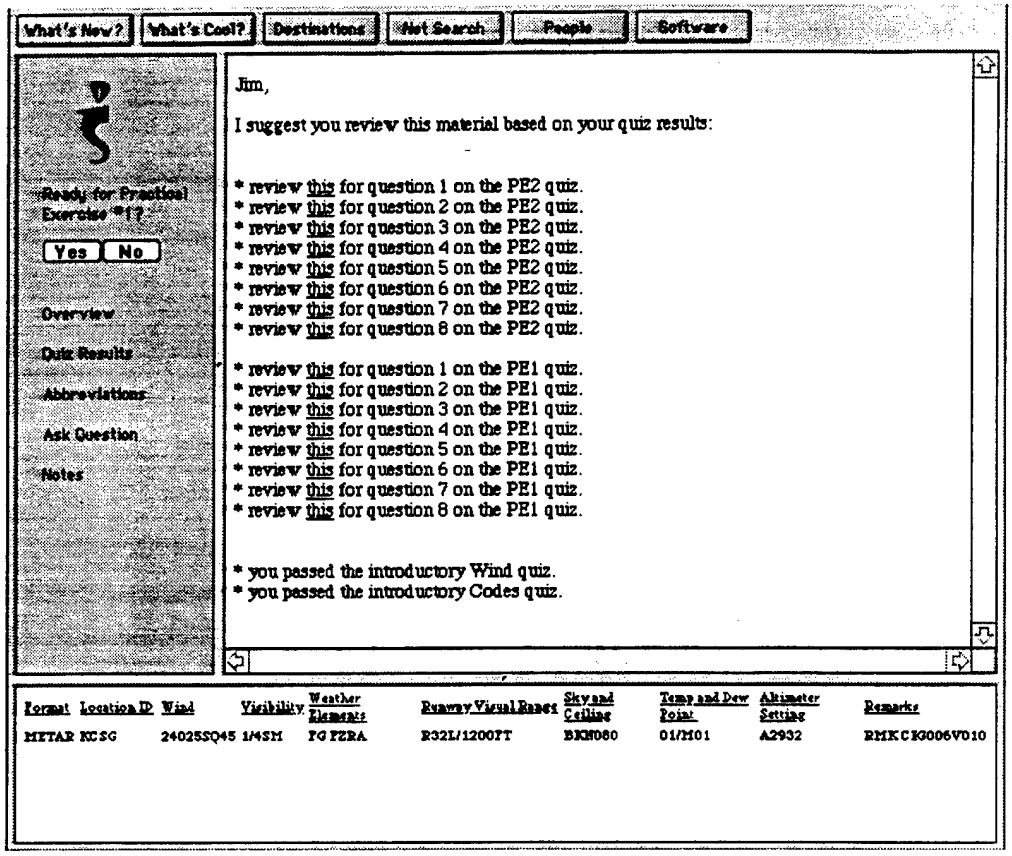

Figure 5.4-3: eClass Agent Exam Review and Guidance

By clicking on the blue links in the quiz results, the student is automatically guided to the content material that they had difficulty with.

This quiz administration capability requires that preset rules be defined for the agent to follow. Using a simple test for conditionality, the agent accesses these rules to determine when an evaluation should be given. In the programming of the applet, each answer has been associated with the Uniform Resource Locator (URL) of the correct answer. A wrong answer invokes this association and the student is given a hypertext link for where to obtain the correct information.

5.5 Content References and Related Links

The prototype eClass Agent provides the student with on-demand references and links to assist in the learning process. This is illustrated in figure 5.5-1:

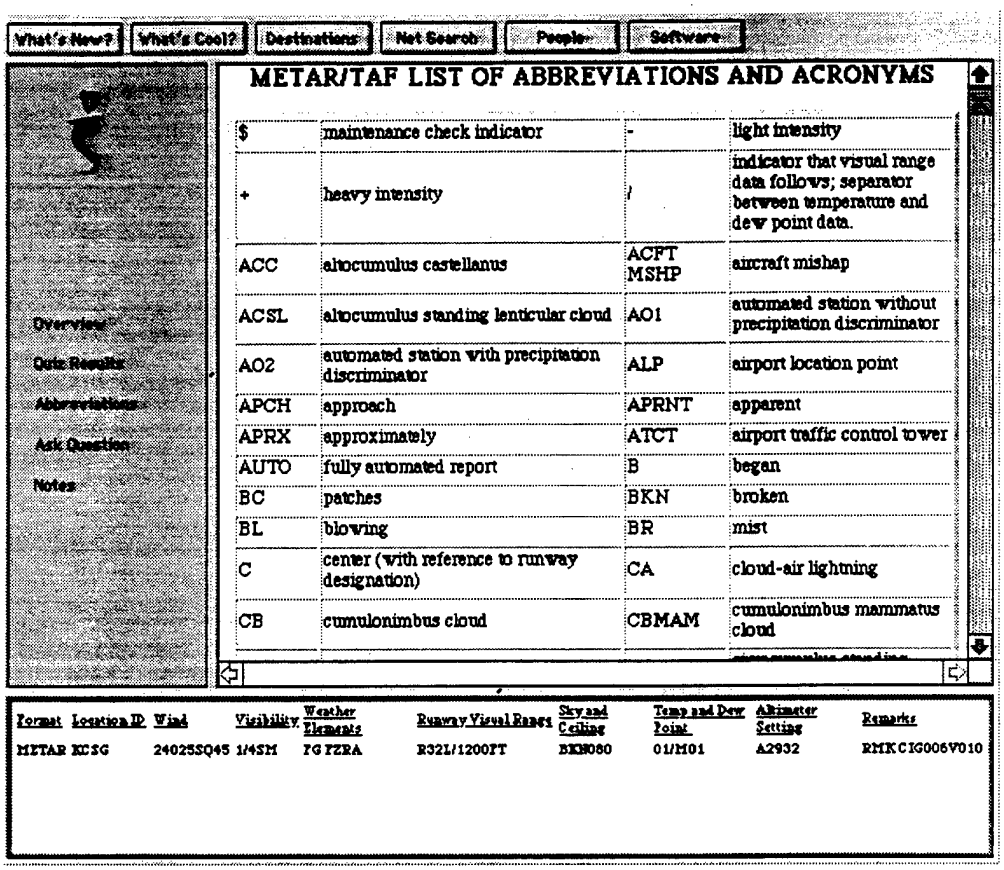

Figure 5.5-1: References and Related Links

This demonstrates how the eClass agent can maintain a consistent source of reference material for the student to review at any point in the lesson content.

5.6 Agent Question and Answer Capabilities

A very useful technical feature of this prototype is the ability for students to ask questions of the agent and for the agent to answer these questions using a knowledge base supplied by the instructor (figure 5.6-1). The student simply types in a question using standard English language, and the agent identifies the corresponding answer based on filtered keywords.

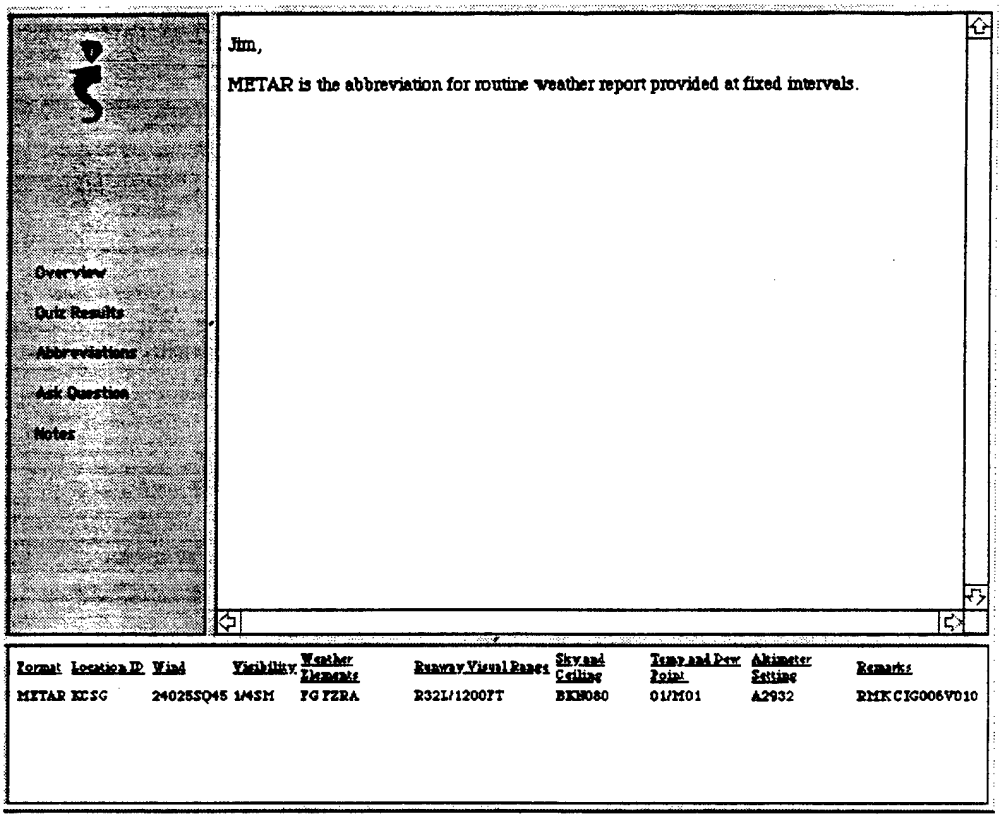

Figure 5.6-1: Q&A Agent Interface

The agent functions as a facilitator, storing questions it cannot answer. These are saved to an administrator's page, usually for the instructor's eyes only (although students might also be allowed to view this if needed). Once the instructor (or any knowledgeable content provider) supplies the answers, the agent emails them to the students who asked. It then stores the answers in the database for future use.

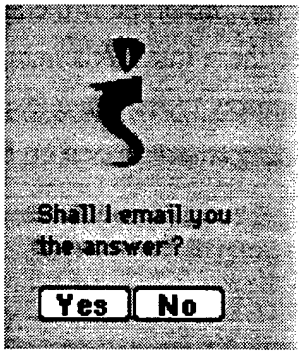

Figure 5.6-2: Q&A Agent Email Capability

The cumulative effect of this two-way interaction is a highly adaptive system that gets better with time. As the instructor answers more questions, the knowledge base grows, and the agent is

better able to provide immediate answers to students. Instructors are free to answer questions asynchronously while students reap the benefits of a synchronous answer bank.

In addition, instead of questions going to a single individual and, as a result, the knowledge base comprising the perspective of one person, an entire team of instructors can use the web based interface to collaboratively extend the database with the collective experiences and expertise of a group.

5.7 Agent Maintains Student Notes

Figure 5.7-1 illustrates the student course notebook which is available to all students using the electronic classroom. The notebook allows the student to keep a collection of notes relating to the course content, and have them available at any point throughout the course lesson.

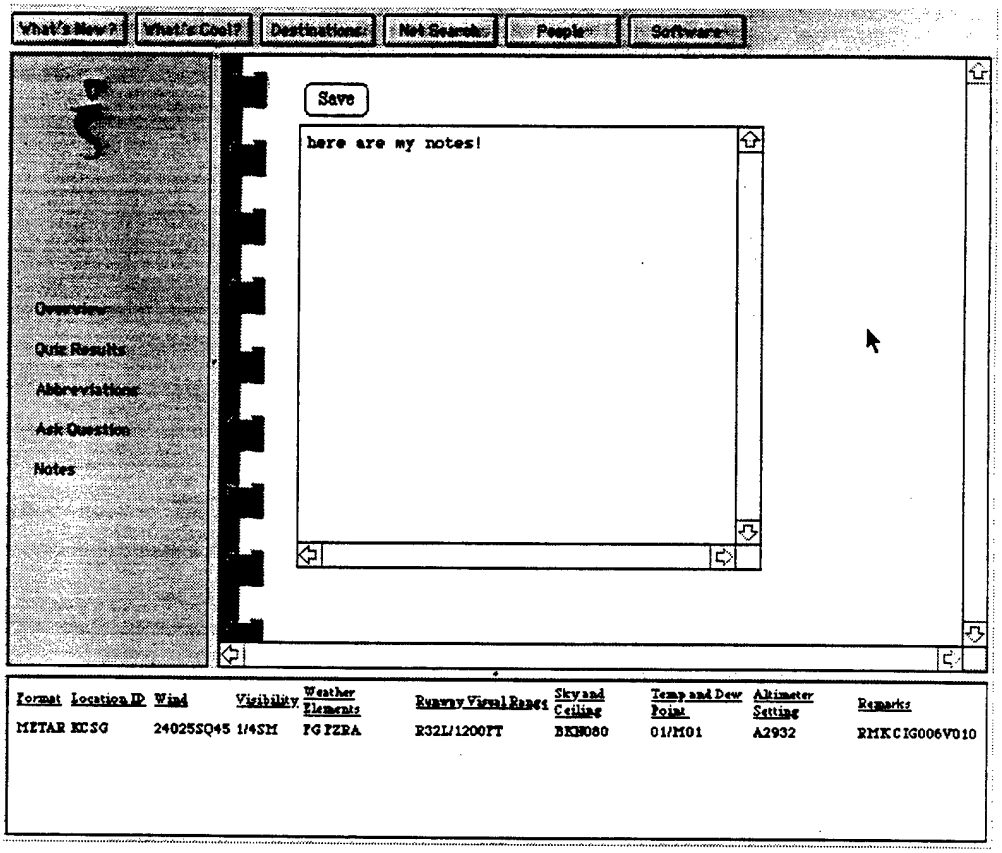

Figure 5.7-1: Student Course Notebook

The coaching agent stores the student notes inside the MS Access database on the server, and displays the notes to the student inside the content frame area when the student clicks on the Note button within the Agent frame area. The student can then read or modify their notes and

then click the Save button to have the coaching agent save the notes for the student. The saved notes are then available to the student each time they enter the classroom.

5.8 Agent Multimedia Capabilities

The prototyped agent-enhanced electronic classroom has been developed with graphic, audio, and video multimedia capabilities. Figure 5.8-1 demonstrates the use of weather graphics for student reference.

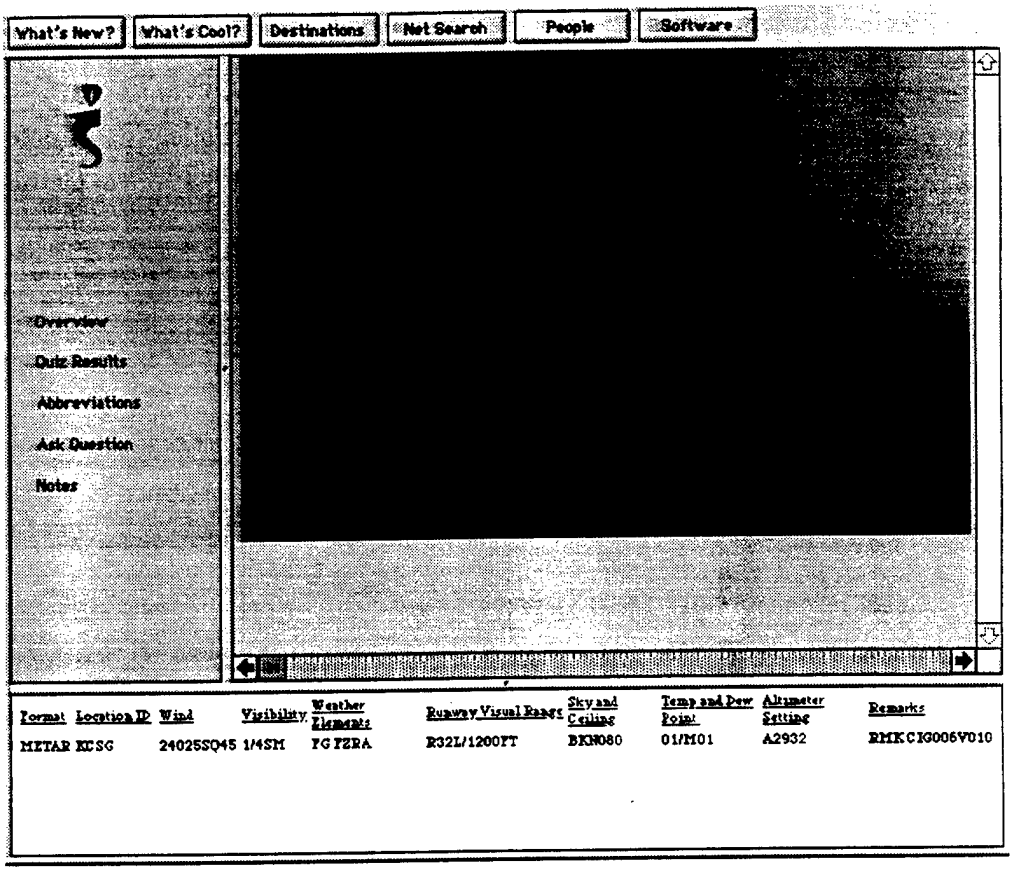

Figure 5.8-1: eClass Graphics Capability

Audio capabilities have been fully utilized throughout the weather training class as illustrated in figure 5.8-2. When a student moves the mouse over a speaker graphic, it hilights and runs an associated audio file when clicked.

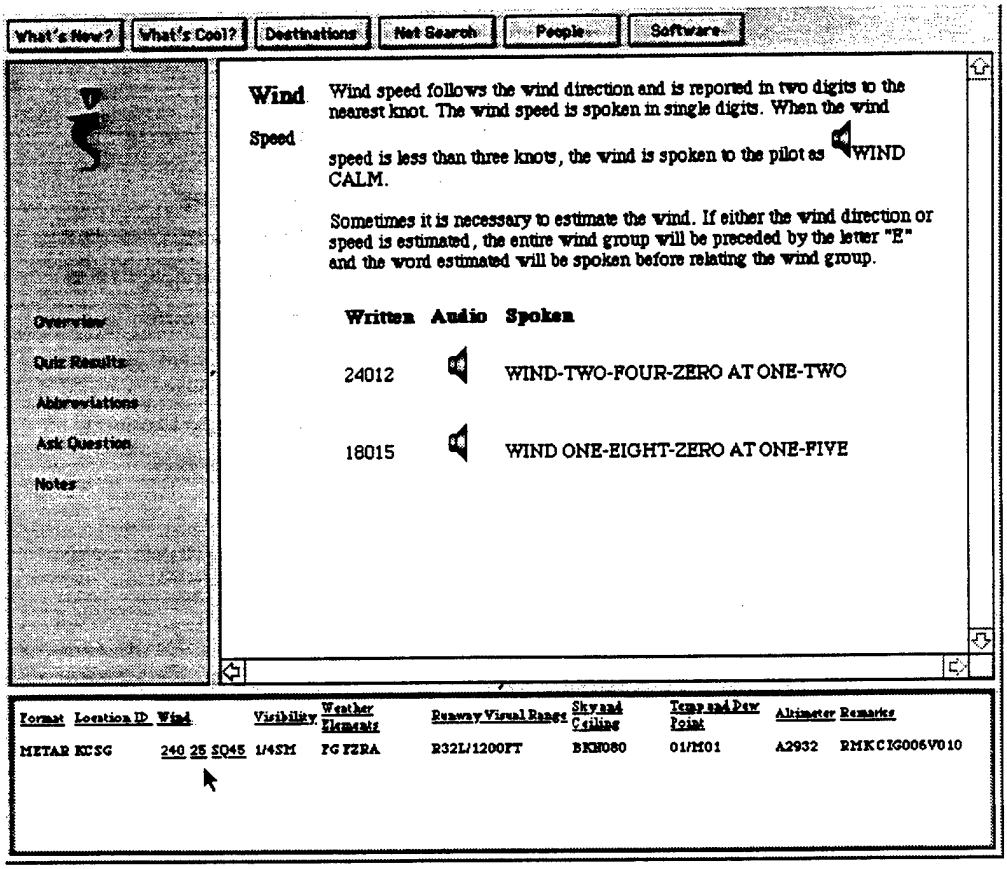

Figure 5.8-2: eClass Audio Capability

For this eClass prototype, the audio files are used to allow a student to hear how a coded portion of the weather report is spoken by an operator. The video capabilities were also prototyped within eClass and made available for investigating external distance learning programs as illustrated in figure 5.8-3:

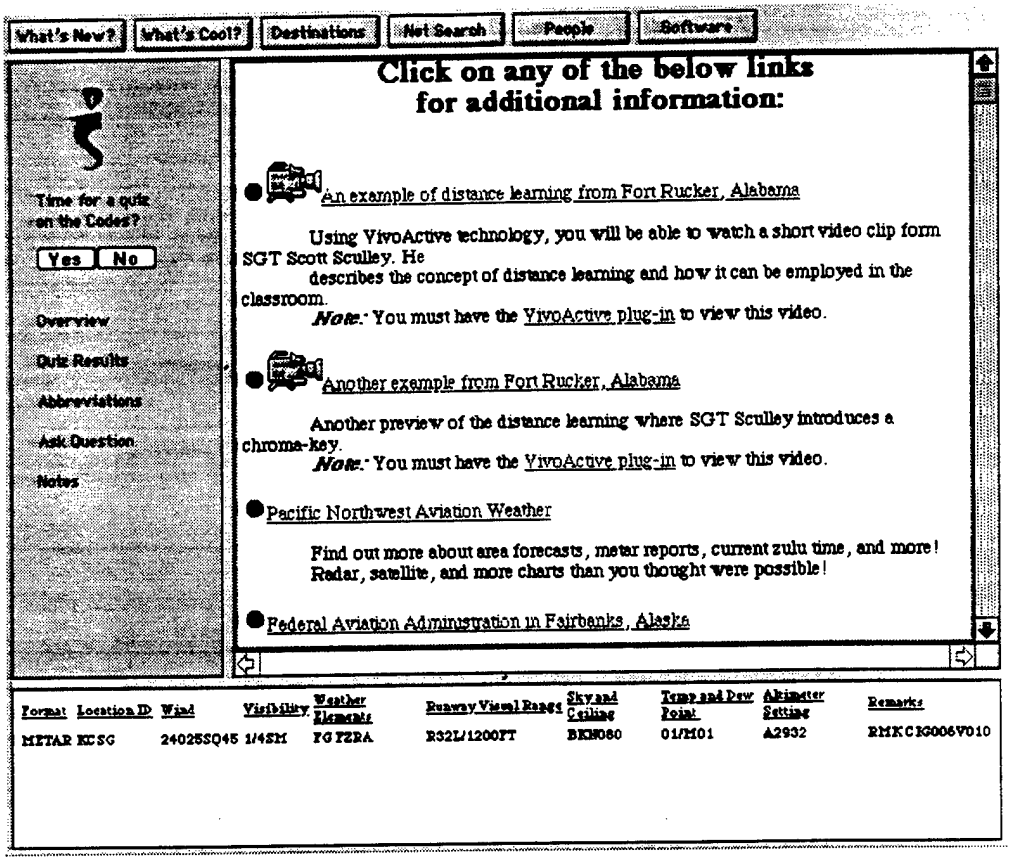

Figure 5.8-3: eClass Video Capability

The eClass prototype requires the VivoActive plug-in to view video files on Windows operating systems. If the student's browser does not have the VivoActive plug-in installed, then the agent will guide the student to where they can download a version over the internet.

6. Prototype Evaluation

The developed Agent-Enhanced Electronic Classroom (eClass) was evaluated for its usefulness within the Weather training course and CyberEd WebCraft course. Both evaluations were found to be very successful, with a number of system improvement recommendations.

6.1 Aviation Weather Training Evaluation by Army National Guard

The prototype eClass for interpreting aviation weather reports was evaluated as part of the Army National Guard aviation training course in Ft. Indiantown Gap in Pennsylvania. Two sets of students used the eClass training, each having access to the web-based course for two days out of their three week training period.

The **first group** of students were used for initial prototype testing, and served well to identify the following *areas of improvement:*

- The coaching agent needed to bring quizzes to students much faster since they were getting preoccupied during self-paced lesson navigation.
- Students needed the ability to tell the coaching agent to administer an exam whenever the student requested one.
- The initial dbANYWHERE database connection was not able to keep up with the fast pace at which students would click on the course material. Therefore, a new Allaire Cold Fusion database connection was required.

The **second group** of Army National Guard students were given access to the completed prototype that was enhanced according to the results of the first group's evaluation. Since there were only six students in this group, statistical averages would not be significant. However, simple plots of the student responses do indicate the overall success of the eClass Weather training. *Appendix A* presents the responses of the six students to a survey completed by them after taking part in the Weather eClass training using the developed prototype.

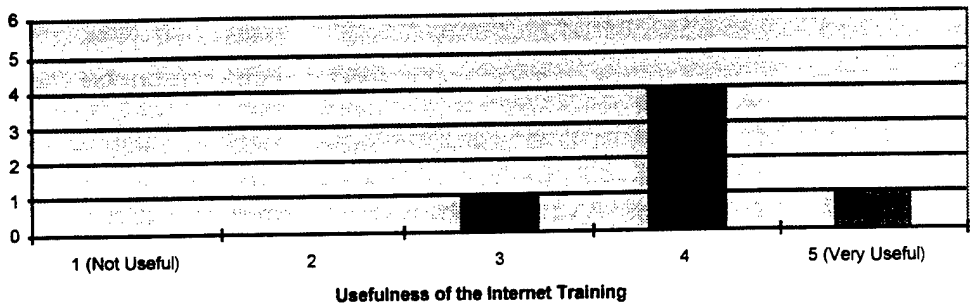

Figure 6.1-1: How useful did you find the Internet training?

A sample of the student evaluation results is illustrated in figure 6.1-1, showing that all the students found the training to be useful and effective within the agent-enhanced eClass internet training. The evaluation results can be summarized in the following areas:

- Students were somewhat familiar with the aviation weather report before using the eClass prototype.
- Most of the students only had one training session with the eClass prototype.
- Students spent 1 to 2 hours using the prototype.
- The majority of students found the eClass weather training to be very useful.
- All students had little to no difficulty using the eClass weather training course.
- Students felt they learned a bit more about aviation weather after using the prototype.
- There was a wide range of internet, computer, computer-based training, and email experience between the Army National Guard students.
- The students had difficulty with the eClass sound capabilities, due mainly with local hardware problems.
- All students felt the material was organized very well and course navigation was excellent.
- Students were satisfied with the quality of the quizzes, though it was clear that some improvement was desired.
- There was plenty of content information for students to learn from.
- The Q&A Agent provided accurate answers to all student questions.
- Most students thought the agent's guidance was helpful, though there is room for improvement.

- Most students felt the agent could have done better in bringing quizzes to them when they were ready.
- Most agreed that it was helpful to have the agent always available to them.
- Students found it easy to get started using the eClass prototype and that the interface was easy to work with.

This summarizes the training evaluation, with the complete results presented in Appendix A. Additional evaluations were performed at UMass Dartmouth using students taking a web-based course through their CyberEd program, and is presented in the next section along with an instructor's evaluation of the prototype eClass.

6.2 eClass Agent Evaluation by UMass Dartmouth

The eClass frame structure and Q&A Agent capabilities were evaluated on students taking the UMass Dartmouth's WebCraft course. The eClass agent was added as an optional link from UMass Dartmouth's CyberEd course environment.

Student reactions: Students from a CyberEd course, reacting informally to the WebCraft eClass agent prototype, all pointed out that the area to ask questions of the agent was too small. Despite the technical limitation of only being able to match a few words to the content of the database records, future development efforts might place the question form in the content frame and give more explicit instruction/explanation of how the Q & A agent works. A larger area to type in questions was requested from six of the nine students who responded with open feedback.

Instructor comments: The following paragraphs present the instructor's comments and suggestions regarding the eClass structure and its application to university courses.

Authoring overhead: The instructional design using this process takes time – approximately five to six hours production time to manufacture a single hour of instruction. This represents a dramatic increase from the three hours of production time needed to yield one hour of material using straight HTML. Future development efforts might be to develop an authoring tool kit that makes file management easier. The navigational menus are easily the most time consuming element of this process.

More real world practice: Simulations might be designed where students are asked to evaluate their own real world response performance. For example, in the Weather module, a scenario could be devised in which a student must decode a weather report in real time and provide a plain English script for radio broadcast.

A more graphical approach: Many of the textual elements used for navigation can be replaced with image icons or icons that used stylized text an colors.

More multimedia: As noted in previous sections, sound files are used where appropriate. However, there are instances where video or audio would better convey a message than the text based counterpart. Development of multimedia approaches would further support content and attract student interest.

Screen real estate: The frames interface might be extremely difficult for users who have small monitors. A non-frames version might be developed that places the agent and navigational elements in the background. Although this may make for an impoverished environment and may negate some of the benefits described above, an alternate design might offer more choices to organizations and institutions limited in hardware resources.

Storing of quiz answers: Currently, students must re-take an entire quiz if they answer any one question wrong on it. A better technical design for how the JavaScript passes answers to the Java applet is needed so that students would only have to retake the portion of the quiz on which they performed poorly.

Reports to instructor: Currently, the prototype eClass does not report back to the instructor about student progress. While students may look at their quiz results in the Aviation Weather module, currently the eClass coaching agent doesn't allow the instructor to view that information.

7. Phase II Requirements And Commercialization

7.1 Incorporate Learn Sesame Server

The Phase I prototype used Java-based local client processing to perform the agent analysis of student navigation and quiz analysis. This enabled a fast development of a feasibility prototype without taking advantage of our full learning capabilities. During a Phase II effort, the Learn Sesame Server will be required to perform the major agent processing to provide the eClass with superior student customization.

Use of the Learn Sesame Server will require architecture modifications to take full advantage of the engine's learning capabilities. The Java eClass agent clients will communicate with a Learn Sesame Server by sending CORBA messages containing the events and objects to be learned. After processing the events, the Learn Sesame Server will send facts back to the eClass agents through the CORBA message format.

7.2 CD-ROM Video Storage Requirements

Computer based training (CBT) is a relatively new topic that large companies are beginning to explore. According to *Training* magazine's 1996 Industry Report, roughly 40 percent of U.S. organizations with more than 100 employees already use CBT for some training applications. With the boom in multimedia and the Internet, corporations are investigating how they can use this new form of technology. Using the Internet, several start-up companies are providing audio and video players available for download. As Charles River Analytics has seen in the on-line classroom, the quality and wait time for video can become tedious for our users.

Bypassing Bandwidth - By having multimedia clips (and other unchanging media) on CD-ROM, users no longer have to deal with bandwidth limitations. We have developed eClass for any Internet browser, and this platform independence is extremely important. Since the majority of course content is static, multimedia components can be placed on a supplementary CD. Even if an individual does not have an actual CD player, the computer will be attached to the Local Area Network. An administrator can then place the CD on a drive accessible to the rest of the students, and they will be able to receive much faster, higher resolution video than previously seen.

Production Costs - The cost of producing a CD is fairly inexpensive, especially if blank CD's are purchased in large quantities. This CD-ROM content can also be developed as a supplementary aid to teachers instead of a stand-alone application, but ultimately our market research will help decide what content needs to be burned onto the compact disks.

The future of this media is uncertain; within the last year there has been much talk about DVD-ROM, which can initially hold three times the information a CD does. Just as the CD's are replacing audio tapes, it is important that we investigate providing new content via this new format.

7.3 Requirements for Chat Rooms

Although the prototype eClass has many interactive features, a chat room is a requirement for distance learning. According to *Training*, "What makes classroom training hard is that you have to adapt on the fly, in real time, to different learning styles. A good live instructor can do that. A multimedia program can't"[1].

Interactivity - The teacher and student can converse in real time. Therefore, students no longer just read content on the screen, but also have an opportunity to ask questions of their professor. Other students may also join a chat forum on a particular topic, making this component multi-purposed. Charles River Analytics will look to purchase one already developed by another software company. Potential customers can then be shown how this chat room, along with electronic mail, can prove to be a very useful addition with distance learning.

Lotus Example - A current company using an on-line course module is Lotus Development Corporation. This software giant supplements conventional teaching methods with Internet training. Explaining the variations in learning, Nancy Leo, manager of curriculum development says:

> "Because technology is technology and people are people, learners are differentiated in other ways. There are people who say, 'I have to go to a class.' There are people who say, 'Don't bother me, I'll learn it when I need it.' "There are people who say , 'Just give me the documents".

Leo says that multimedia is most effective for "discovery learners", but that "those people are not in the majority"[1]. Therefore, most of training at Lotus continues to be held in a classroom and instructor based. Successful multimedia based distance learning is trying to find the right combination of software to meet the most general audience, and the ability to talk with one another is a substantial component.

7.4 Requirements for a Progress Indicator

Currently, students in our on-line classroom may select "Quiz Results" to see which quizzes they have passed. Hyperlinks from each quiz brings the student back to a specific chapter he or she need to focus on if they had not passed the quiz. We need to build upon and add new

features that are still accessible to any student using a current Internet browser (Netscape Navigator or Internet Explorer). This new object, renamed "Progress Indicator," shows the student all of the relevant information and how he or she is currently doing on a particular course. To demonstrate these new components, we investigated the on-line SEC Series 7 exam. A student clicks on Progress Indicator from the main menu. Once inside, he or she sees the following: Student Information, SEC Content Covered, Agent Advice, Quiz Results, and Instructor Remarks.

Student Information - As with the other newly introduced components, Student Information will be interacting with an SQL database, namely Informix for Windows NT. Data such as the course length, student e-mail address and other relevant facts will reside here. The student is allowed to change only his or her e-mail address from this region.

SEC Content Covered - This component provides the user with a graphical representation of the sections they have covered. This Java-based applet will be developed to interact with our Cold Fusion database server. The student can see different color coded sections showing how they are doing individually on the course material. Since we are already tracking every page the user visits, this new applet will be easy to implement. The student has control over the colors by using a mouse to double click on the applet.

Quiz Results - This component is similar to the SEC Content Covered in that students will see how many quizzes remain and what has been completed. The colors and graphics used are visually appealing to the student, so information does not appear too static. Audio clips can even be attached to each quiz successfully passed in order to entice the student to continue his or her progress. From the Quiz Results section, students can click on any of the quizzes listed to immediately be tested.

Agent Advice - Agent Advice automatically recommends the reviewing of certain areas if the student has been having trouble on the quizzes. Since this feature has already been developed, it will be incorporated into the Progress Indicator with the other components. Students can click on a hyperlink to review the topics suggested, and our on-line classroom continues to prompt them when it is time for another quiz.

Instructor Remarks - This text field is where the instructor can review each student's progress and write individual or class notes available to him or her. A picture of the professor as well as the opportunity to respond to his or her comments via e-mail will also be available through the Progress Indicator page.

Please refer to Figure 1 for the complete Progress Indicator layout as viewed by a Netscape Navigator user. Also note that any number of the above components can be removed or placed elsewhere within the Progress Indicator. The diagram represents the full featured applets in a Hypertext Markup Language document using a Java enabled web browser. JavaScript continues to check if the system meets the given requirements before continuing into the on-line classroom.

7.5 Desktop Video Conferencing

In addition to the chat application, it is necessary that Charles River Analytics investigate the possibilities of desktop video conferencing. Since students may be located all over the world, face-to-face contact is extremely difficult without video conferencing. Although the technology is in its infancy, video conferencing software is yet another way for students to ask teachers and other classmates questions about the course they are studying.

There are several companies offering free conferencing software for the Internet, including Microsoft Corporation and White Pine Software. Microsoft's Net Meeting is ideal for distance learning in that it offers decent frame rates, whiteboard collaboration, and file transferring. The file transferring allows teachers and students to download documents, audio files, and any other relevant course information onto his or her individual computer. Whiteboard sharing lets two users exchange ideas over a blank white screen, while still keeping the video conferencing intact.

Although two-way digital video-conferencing has bandwidth limitations, it still can be used as another way to convey a message to students. "As advanced fiber-optic networks and improved compression techniques become widespread, this technology is likely to play a more significant training role" [2]. Because video-conferencing is still in its infancy, many companies have not seriously weighed the benefits. This technology is primarily used as another means to convey information to the student. Both instructors and students will have to spend more time learning how to use the software, but when multimedia interaction between teacher and student is needed, Charles River Analytics will not overlook this useful component to our on-line classroom.

An example use of video conferencing software would be a student who has trouble understanding a chapter from our on-line classroom. He then meets with his instructor at a designated time, while they converse using a digital camera and speaker. Using a combination of audio, video, and graphics the student then has a better understanding of his difficulties.

By using software already in existence, Charles River Analytics does not need develop this technology in-house. Once acquired, our video conferencing component is yet another learning tool that can be used to market to our potential customers. The only equipment that our

customers may not have are the digital cameras, as they are not standard with most new computers being shipped. Steve Willett, founder of Prosoft distance learning software says:

> "An instructor brings a whole persona that can never be emulated by a machine. Everyone who comes through a training classroom thinks in a different way and wants to go down a different avenue with the content" [1].

By introducing video-conferencing, this is another option corporations can use to supplement the learning process. As with our other components, we must deal with each client on a case by case basis and look at their needs to ensure a successful distance learning software solution.

7.6 Developing a Business Model

There are several different business models currently being used which are profitable on the Internet. In a *Marketing Management* article by Bruce H. Clark, he details the reasons to use each plan for generating revenue. However, the initial business plan for the on-line electronic classroom consists of the following mix: The Cable TV Model, The Customization Model, and The Subscriber Model.

The Cable TV Model - Clark says that a company would "provide a selection of advertiser-supported free content while charging customers for the premium content" He later notes that "a further advantage of this model is that the free content acts as a sampling device for the premium content. Occasional free trials of the premium content may convert visitors into subscribers" [3]. Internet users who "surf" onto Charles River Analytics web site will find our distance learning section, and be able to partake in a working demo. After filling out some information for us, we can record the amount of users looking at our demo, and contact them a short time later. In the Cable TV Model, our company should not show advertisements, only limited free content.

The Customization Model - This particular business model will "charge customers for content that is customized to meet their preferences. This model, also relatively new, takes advantage of database software and the Web's low marginal cost of information transmission" [3]. This strategy works well with the marketing of corporate clients. If Charles River Analytics can purchase the rights to use material for a classroom, we can then directly market to Intranets. Each client's needs will vary, so we can select certain components to fit their corporate needs. The database software we use to track students and visitors to the web site already exists, therefore customizing software is one model of attracting commercial clients.

The Subscriber Model - The focus of this model is to charge customers for the content they view. Similar to the Cable TV Model, this is an excellent way for our company to receive profits from single users. If an individual is preparing for the SEC Exam, and not affiliated with any

company, he or she could take the course off of our web site during the specified times. These customers will pay us for a flat rate to use the classroom, and in return, have access to all of the components we have developed.

Consequently, the above business models blend together. We can effectively market to the individual Internet user and corporate Intranets, as well as offer methods for negotiating with content providers.

7.7 Commercial Web Delivery Mechanisms

As most serious Internet users know, bandwidth throughput will play an important role in the future of the web. Companies who want to deliver information to their employees have to deal with these limitations. "Although interactivity is a valuable part of Intranet technology, many companies have yet to use it. In fact, most Intranets still function as virtual warehouses of static information" [4]. Fortunately, there has been much recent development in this new area of bandwidth. The increase in bandwidth can be applied to both our stand-alone users as well as the corporate Intranet market. This topic is investigated because Charles River Analytics' success in distance learning depends on the quantity of content, and the speed in which it can be delivered to our customers. The following modem technologies are investigated: ISDN, Cables Modems, and ADSL.

ISDN - ISDN (Integrated Standards Digital Network), unlike Cable Modems and ADSL, have been around since the 1970's. ISDN is currently offered by several of the large telephone companies for a premium price, but offers a capacity of only 128 kpbs. This rate is terribly slow when compared to 9 and 10 Mbps offered by the competitors. The only major advantage ISDN users have is that it is a solid product that delivers home users faster access rates than 28.8 kpbs. Unfortunately, the high maintenance costs and slow bandwidth rates can force this technology to become obsolete when the competition gets approval from the FCC and telephone companies.

Cable Modems - Cable companies are investing millions of dollars to develop Internet access through box top sets. These modems allows for users to receive information at rates as high as 10 Mbps. This is obviously far greater than today's modem speeds of up to 56 kpbs. There are two general applications that can be used for these higher speed modem: "interactive video and high speed data communications" [5]. The downside to this new technology being developed is that users must share this capacity with others who are located on the network. Thus, the download transfer rate can become significantly less, as other users log on.

ADSL - ADSL (Asymmetric Digital Subscriber Line) has much more potential, and future use, than Cable Modems. "The strength of ADSL compared to other high speed transmission

alternatives lies in the number of existing telephone lines - now approaching 700 million - compared to new cabling which has reached comparatively few homes and no small businesses" [5]. The customer using ADSL technology has a downstream of 9 Mbps, but unlike the Cable Modem, does not have to share this bandwidth rate with others. The majority of U.S. households and businesses have phone lines in place, so once ADSL is implemented by the telephone companies, end users will see a huge difference in the speed of accessing data.

Charles River Analytics can be confident that our distance learning software will become faster in time, due to the new developments in modems and access times. ADSL allows for our video player to no longer look "choppy" or compressed, but to smoothly flow from frame to frame. Therefore, much more video content can be stored at the corporate web sites. Soon, video will not need to placed onto a CD-ROM, but can be stored on a server for immediate retrieval. This reduces our costs in production, and allows for repeat customers to ask for more video content in their particular classroom. The faster speed of the Internet will enhance our classrooms in all aspects, ranging from corporate Intranets to stand-alone customers who wish to self-study one of our on-line courses.

7.8 Web Television Market

Until recently, personal computers and television sets were thought of as two separate applications. However, within the last few years, the general public has quickly started to adopt the Internet as a new medium in receiving information. Companies such as WebTV realized that many households did not want to spend thousands of dollars buying an Internet-ready computer. Engineers realized that the television sets can be easily converted into an Internet browser similar to what the video game industry had accomplished.

Predicting the next few years, *Marketing Management* writes:

> "the future will be powerfully affected by how quickly Internet access grows for businesses and consumers and by how quickly Internet capacity expands. Audio has already arrived on the Web, and full-motion video will eventually join it, revolutionizing what we can do on Web pages. Simpler Internet-access devices such as WebTV and faster Internet-access technologies such as cable-modems promise a broader, faster, richer World Wide Web in the future" [3].

The future of the Internet depends on how many people can access the networks and at what speed the information is received.

With the example of WebTV, there is no software needed. After purchasing a WebTV Internet terminal, a customer uses their telephone line to connect to WebTV's local Internet

Service Provider. The near future will bring many more smaller, easy-to-use applications for accessing the Internet. Fortunately, Charles River Analytics' electronic classroom will be compatible with these new technologies such as WebTV, because of the programming language used, and the current standards the software industry established.

8. Summary, Conclusions, and Recommendations

In this chapter we summarize our findings (section 5.1), present our conclusions (section 5.2), and offer recommendations for a follow-on Phase II effort (section 5.3). Finally, in section 5.4 we explore the commercialization potential of the core technology developed in this effort.

8.1 Summary of Phase I Effort

Our Phase I study centered on the development and feasibility assessment of an agent-enhanced electronic classroom for the web. Six development tasks comprised our effort:

- Identification of State-Of-The-Art in Electronic Classrooms
- Determination of Prototype Lesson Domain
- System Architecture Design
- Implementation of a Limited-Scope Prototype
- Demonstration and Evaluation of Concept Prototype
- Requirements Specification and Commercialization

We first defined the Phase I problem scope. This involved consultation with the sponsor, through which we selected the *interpretation of aviation weather reports* as the lesson content for the prototype electronic classroom. The following requirements for the Phase I effort were identified:

- The lesson content must have inherent structure that can be navigated by students.
- The lesson must be testable through multiple choice questions
- The tutor agent must monitor student progress through content
- The tutor agent must administer exams and provide coaching
- The electronic classroom must demonstrate multimedia capabilities
- The electronic classroom must be extensible to other lesson content
- The agent tutor must facilitate student-instructor interaction and communication

With the problem scope and requirements identified, the target lesson content was selected to be a limited subset of the Army National Guard Aviation Training course. The selected subset of aviation training was Interpreting Aviation Weather Reports. This content provided a complete lesson that could be presented in its entirety, while remaining small enough to complete in the Phase I timeframe.

The agent-enhanced electronic classroom (eClass) architecture was chosen such that it would be easily extensible for additional in-depth content and to other lesson domains. To accomplish this, a Java-based client-side implementation was used along with Cold Fusion server-side connections to a MS Access database. All relevant lesson content information is stored within MS Access tables and HTML files, while the Java code contains the agent tutor rules and general eClass functionality. In this manner, lesson content can be easily modified and replaced without changing the basic functionality of the eClass and its agent tutor.

The eClass architecture was prototyped for the aviation weather report training, and is available at *http://agents.cra.com/eclass* for demonstration purposes. The results obtained from this Phase I prototype effort can be summarized as follows:

- a three-frame approach to the eClass user interface provides a consistent learning environment in which there are designated areas for student self-paced navigation, agent tutoring interaction, and lesson content presentation.
- the eClass client-server architecture is capable of accommodating a large range of training content, providing easy customization for developers and simplified maintenance for instructors.
- the Agent tutor is effective in monitoring student navigation through course content, capable of administering exams when needed, successfully corrects exams, and provides accurate coaching for areas the student had difficulty with.
- the Question & Answer Agent component of the prototyped eClass successfully provides direct and accurate answers to student questions, decreasing the load on actual course instructors.
- the Question & Answer Agent component is capable of serving as a stand-alone service, and was demonstrated for the commercial OpenSesame web site, Charles River Analytics intranet, and UMass Dartmouth CyberEd course.
- the prototyped eClass for Weather training was evaluated by two groups of Army National Guard students. Feedback from the first group of students was used to modify the agent functionality for the second group. The second group of students successfully completed the eClass training using the on-line prototype.

Based on the results of our Phase I effort, the agent-enhance eClass architecture has significant commercial potential for military, university, and corporate training applications.

8.2 Conclusions

We believe that the Phase I results demonstrate basic feasibility of the concept prototype for an agent-enhanced electronic classroom on the web. The study was specifically structured to be narrow in scope, but of sufficient depth to set the foundation and to provide a roadmap for a Phase II full-scope development and validation effort.

Our study has shown that the agent-enhanced approach works well in delivering training that is personalized to each individual student needs. We have designed and demonstrated a Java-based electronic classroom architecture that runs in the web browser environment and is accessible to students at any time, from any location in the world. Our effort has set the foundation for a web-based-training course delivery mechanism that can easily be customized by instructors for a variety of training domains.

In summary, we believe that our overall Phase I effort has established the feasibility of developing a full-scope agent-enhanced electronic classroom that uses the Learn Sesame personalization engine to provide the highest level of student personalization and targeted training on the internet.

8.3 Recommendations

On the basis of the Phase I results, we recommend a Phase II effort to develop, validate, and demonstrate a full-scope agent-enhanced electronic classroom. The following specific objectives shown in Table 8.3-1 comprise our proposed effort:

Table 8.3-1: Features of Phase I and Phase II Efforts

Feature	Phase I	Phase II
Objective	Establish feasibility of electronic classroom	Develop full-scope prototype electronic classroom
Focus	Content presentation and multimedia delivery Communication Knowledge base maintenance for lesson information Dynamic FAQ maintenance Example electronic classroom	Phase I features Recognition of learning difficulties and knowledge deficiencies Learning the communication style preferences of the user Personalized service environment for students Recognition of student's learning style
Scope	Single classroom with limited behavior learning and communication	Multiple classroom with full-scope learning and communication
Approach	Concept prototype development and demonstration	Prototype enhancement, demonstration and evaluation
Content presentation	Hypertext for text presentation Java interactive applets	Hypertext and interactive applications Java interactive applets 3-D graphics Real-time audio Video clips presentation Video conferencing
Communication	Email	Email Whiteboard, Chat Collaboration on documents between students and instructors Meetings between students and instructors
Knowledge base maintenance	Students performance	Students performance Students learning style
Dynamic FAQ maintenance	Exact by word recognition	Fuzzy by word recognition
Learning	Limited learning of students performance	Full-scale learning of student's performance Students areas of mastery or difficulty Groups of students areas of mastery or difficulty Navigational pattern
Example scenario	Aviation weather report electronic classroom	Enhancement of aviation weather report electronic classroom MOUT training simulation Flight plan training Additional university classes Corporate training UMass WebCraft electronic classroom

9. References

ADSL Forum, "Frequently Asked Questions" On-line: http://www.adsl.com, April 1997.

Caglayan, A. K., & Snorrason, M. (1993). "On the Relationship Between the Generalized Equality Classifier and ART2 Neural Networks". *World Congress on Neural Networks '93*, Portland, OR.

Carpenter, G. A., Grossberg, S., & Rosen, D. B. (1991). "ART2-A: An Adaptive Resonance Algorithm for Rapid Category Learning and Recognition". *Neural Networks*, 4, 493-504.

Lengyel, R. E. (1996). "Battle Command Training Directorate",

Mazzu, J., Caglayan, A., & Jonas, M. (1991). *A Hybrid Neural Network Expert System Environment* (NAS9-18479): NASA Johnson Space Center (August).

Mazzu, J. M., Snorrason, M. S., Caglayan, A. K., & Wilkinson, D. J. (1994). *A Hybrid Intelligence Engine for Nucelar Monitoring* (Final R9222): Charles River Analytics (31 August 1994).

Norman, K. L. (1994). "HyperCourseware", http://www.lap.umd.edu/hcwFolder/hcwHome.html

Snorrason, M., & Caglayan, A. K. (1994). "Generalized ART2 Algorithms". *World Congress on Neural Networks*, San Diego.

Stone, G. (1996). "What is CyberEd",

Witten, I. H., Moffat, A., & Bell, T. C. (1994). *Managing Gigabytes*. New York, NY: Van Nostrand Reinhold.

10. Appendix A - Student Evaluations

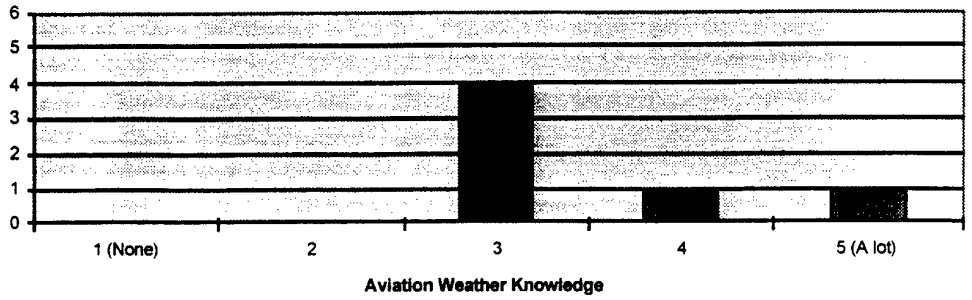

Figure 10.1-1: How much did you know about Aviation Weather before the MOS 93P training started?

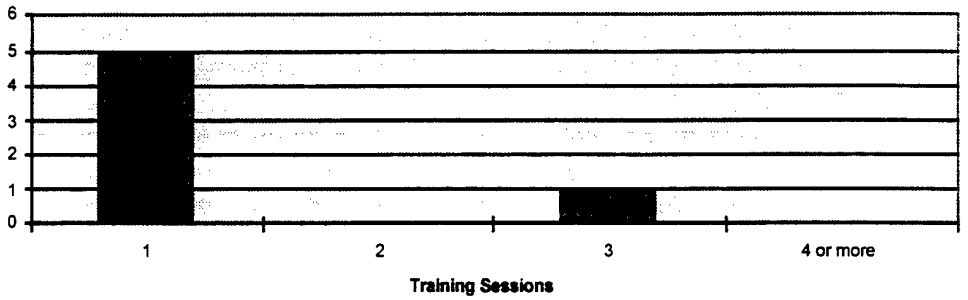

Figure 10.1-2: How many training session did you have on the Internet for Aviation Weather?

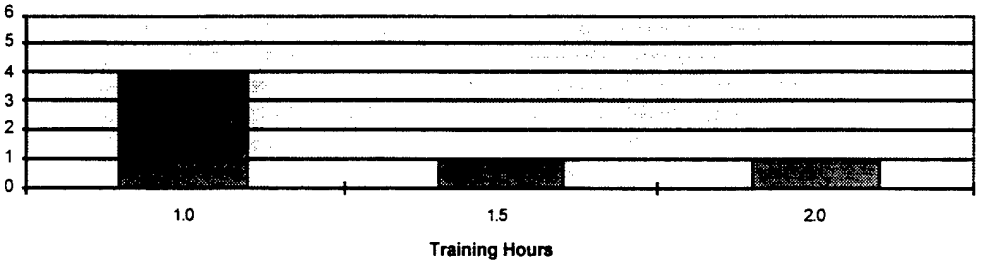

Figure 10.1-3: How much total time did you spend on the training?

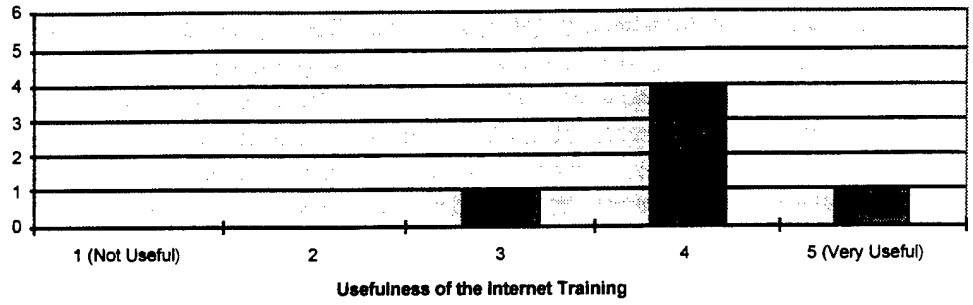

Figure 10.1-4: How useful did you find the Internet training?

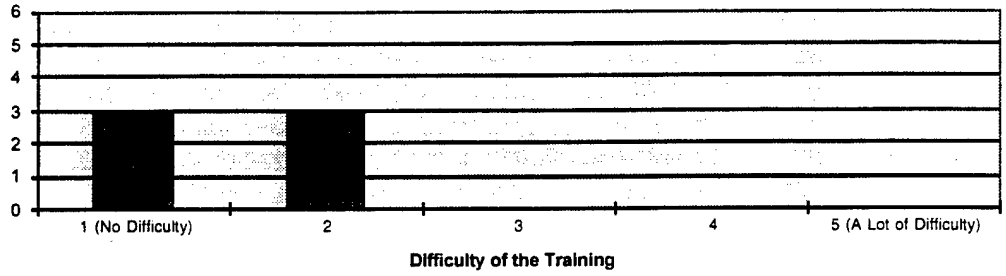

Figure 10.1-5: How much difficulty did you have using the Internet training?

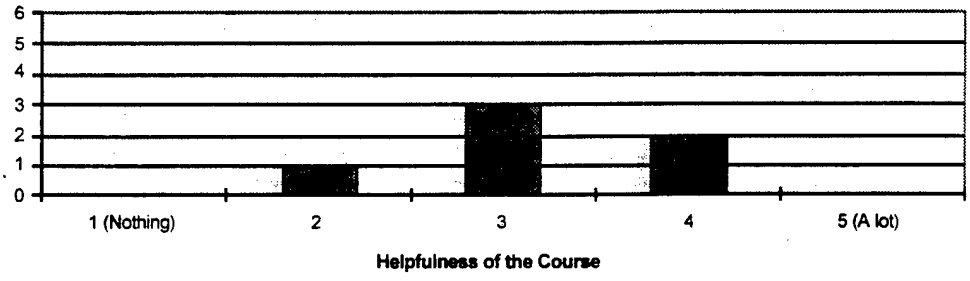

Figure 10.1-6: Compared to what you learned about Aviation Weather during classroom training, how much more did you learn from the Internet training?

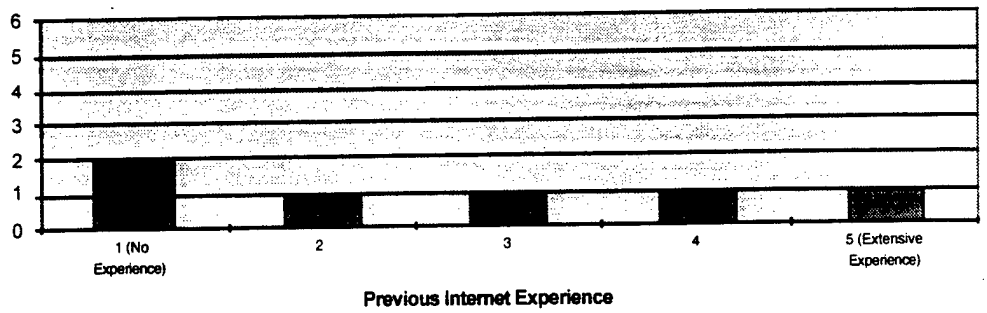

Figure 10.1-7: How much previous hands-on experience did you have with the Internet?

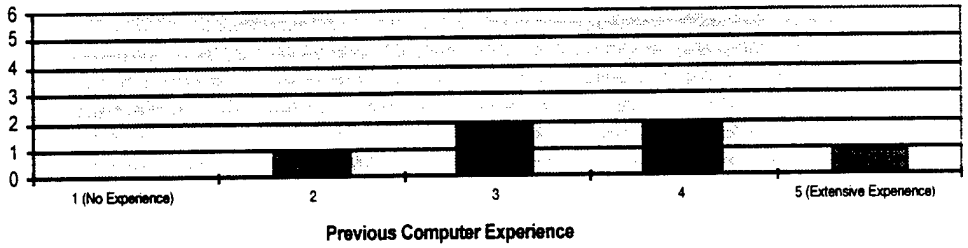

Figure 10.1-8: How much previous hands-on experience did you have with the computers?

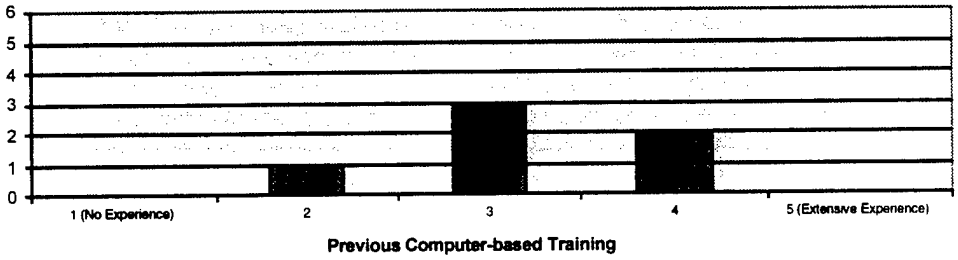

Figure 10.1-9: How much previous hands-on experience did you have with the computer-based training?

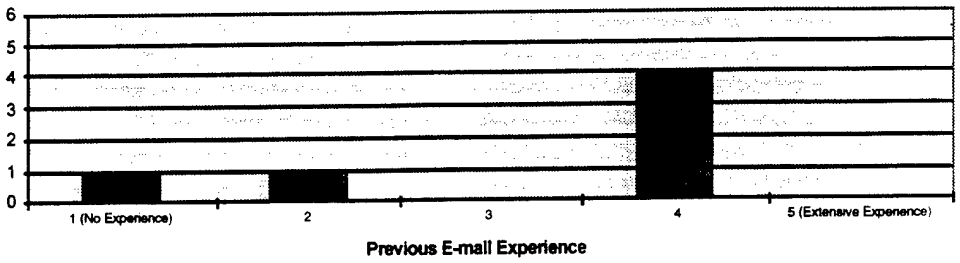

Figure 10.1-10: How much previous hands-on experience did you have with the email?

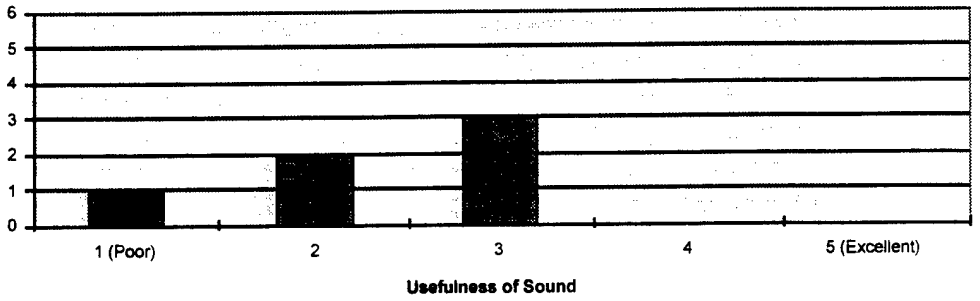

Figure 10.1-11: How would you rate the sound characteristics of the MOS 93P Internet training?

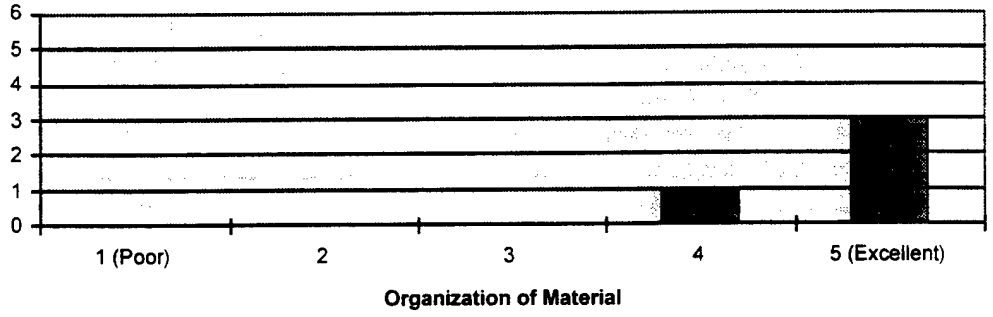

Figure 10.1-12: How would you rate the organization of material?

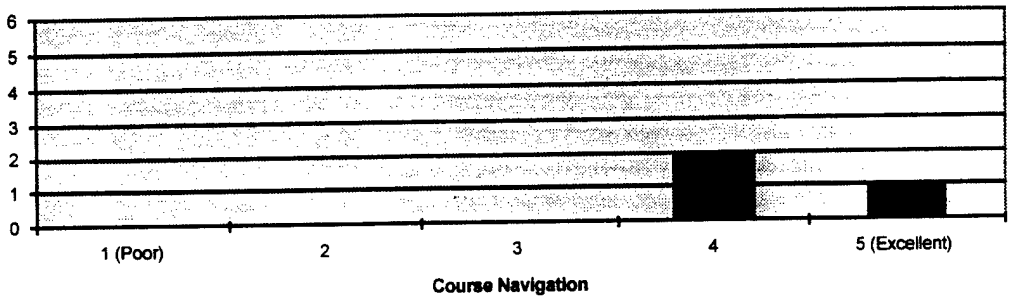

Figure 10.1-13: How would you rate the course navigation?

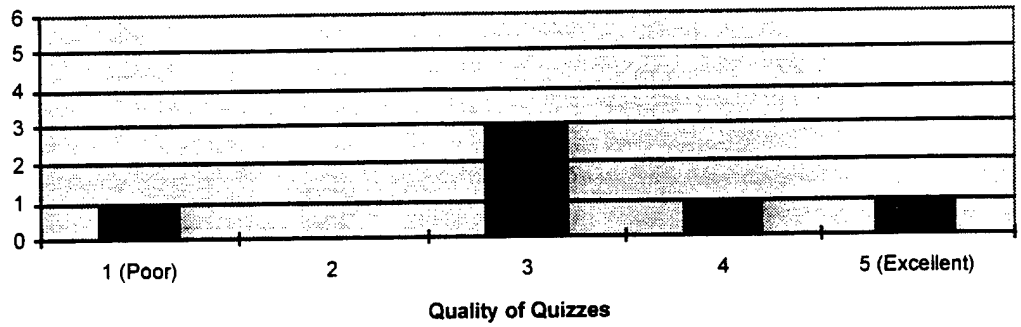

Figure 10.1-14: How would you rate the quality of quizzes?

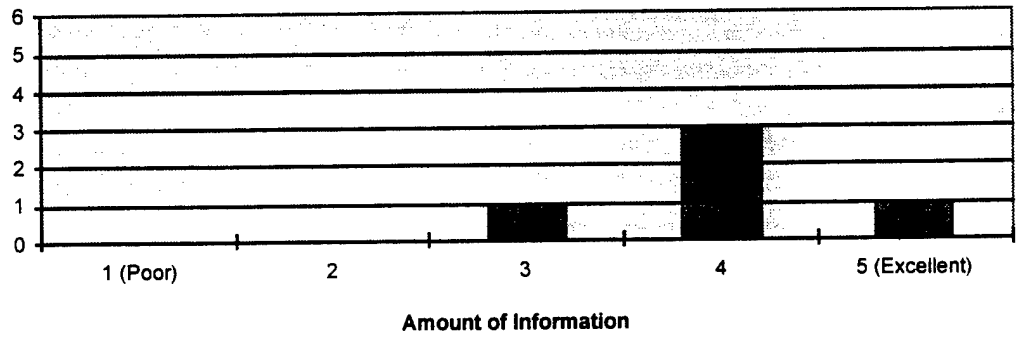

Figure 10.1-15: How would you rate amount of information provided in each weather report?

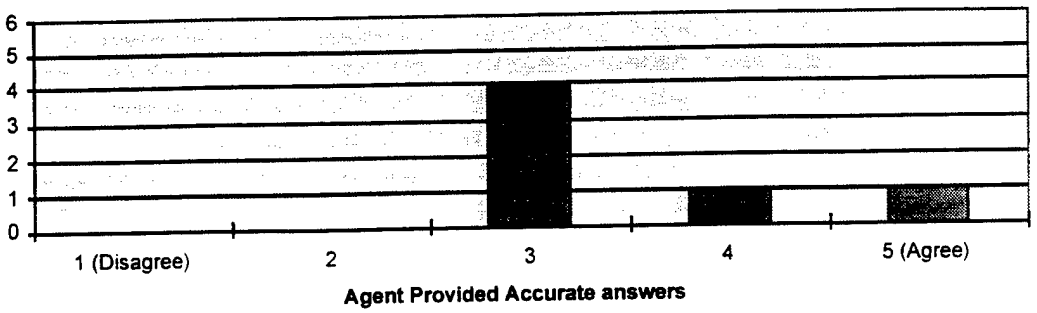

Figure 10.1-16: The agent provided me with accurate answers to my questions.

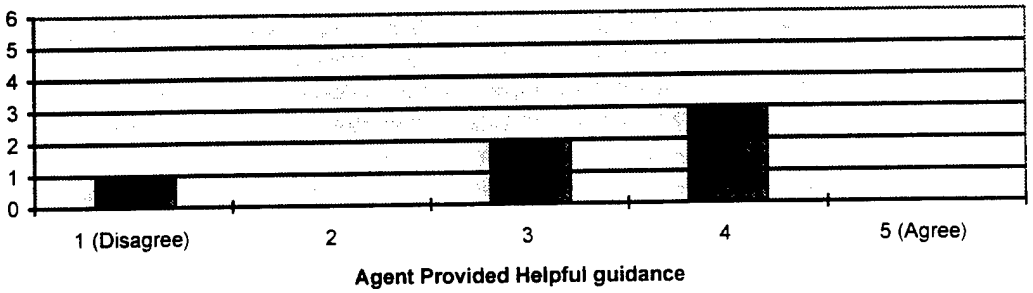

Figure 10.1-17: The agent provided helpful guidance based on my quiz performance.

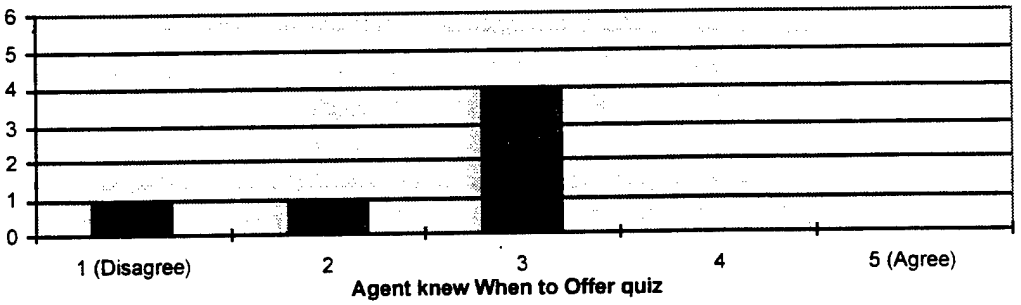

Figure 10.1-18: The agent knew when I was ready to take a quiz.

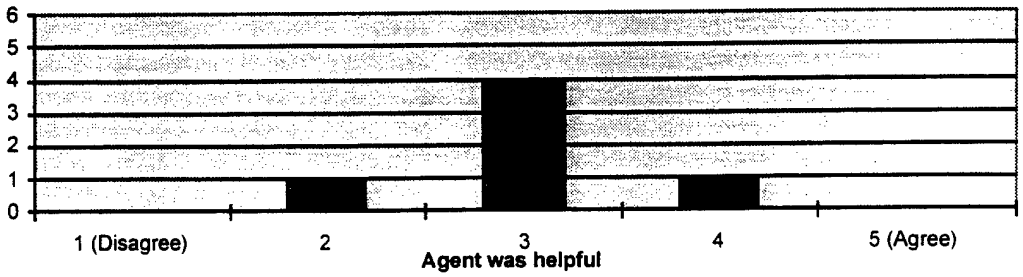

Figure 10.1-19: It was helpful to have agent always available to me.

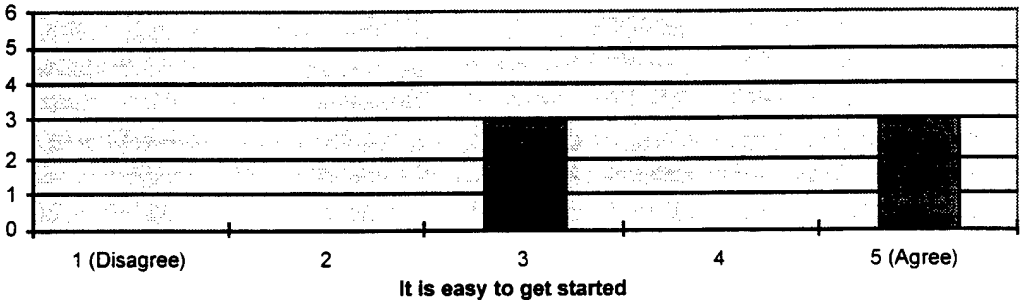

Figure 10.1-20: It was easy to get started using the electronic classroom.

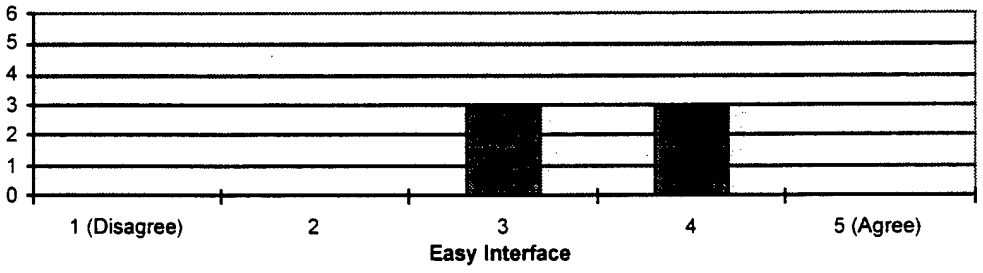

Figure 10.1-21: The electronic classroom interface was easy to work with.

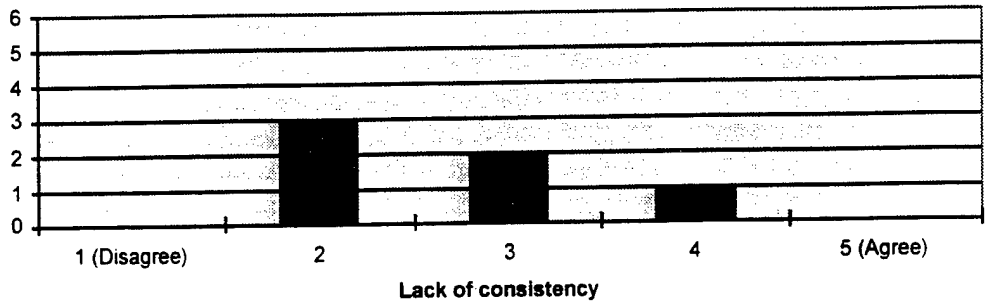

Figure 10.1-22: Lack of consistency made learning the made learning the material difficult.

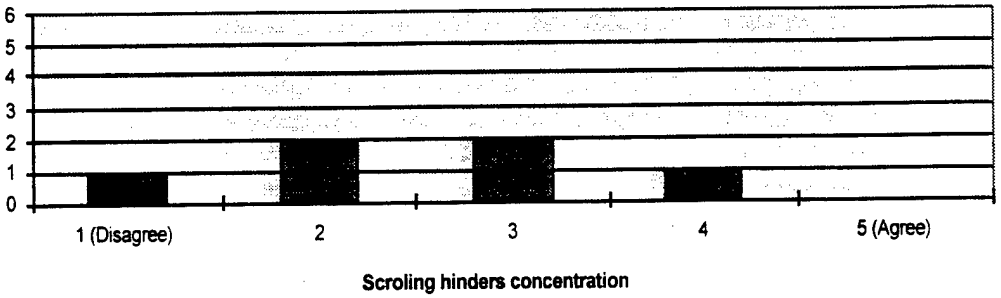

Figure 10.1-23: Scrolling in the content screen interfered with my ability to concentrate.